Vol. 22, No. 8, Journal, pp. 247-278
THE JOURNAL and CERAMIC ABSTRACTS, AUGUST, 1939
18-8 Ceramic Abstracts, pp. 197-216

THE JOURNAL and CERAMIC ABSTRACTS

AMERICAN CERAMIC SOCIETY

SEPTEMBER • 1939

MONTHLY PUBLICATION DEVOTED TO THE ARTS AND SCIENCES RELATED TO THE SILICATE INDUSTRIES

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Publication Office; 20th & Northampton Sts., Easton, Pa.
Editorial Office; 2525 N. High St., Columbus, Ohio
Entered as second-class matter at the post office at Easton, Pa., under the act of March 3, 1879. Published monthly.
Subscription fifteen dollars ($15.00) a year. Single numbers $1.50
(Foreign and Canadian postage, 50¢ additional on subscriptions)
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ADAPTING MINIATURE CAMERAS TO PETROGRAPHIC PHOTOMICROGRAPHY*

By Paul S. Dear

Abstract

A simplified, composite apparatus by means of which miniature cameras may be adapted to the work of petrographic photomicrography is described. An assembly drawing of the various component parts is included, and examples of the application of the apparatus to problems in ceramic technology are given.

I. Introduction

The use of photomicrography in relation to many fields of industrial and scientific work is becoming increasingly important and beneficial. This is evidenced in the realm of ceramic technology by the many photomicrographic illustrations accompanying technical articles appearing in recent journals.

Photomicrographs offer a convenient method of preserving records of structural and phase relations in the many kinds of ceramic products, not only during the manufacturing process but also after the exposure of the finished products to service. To cite a single example, much of the fundamental knowledge concerning the manufacture of silica brick and their behavior under service conditions has been preserved through photomicrographic technique.

In order to make the use of photomicrography convenient, simple, and inexpensive to users of petrographic microscopes, which at the present time are not equipped with photographic attachments, this article has been prepared.

II. Apparatus

(1) General Requirements

Apparatus designed for photomicrography should fulfill the following requirements: (1) it should be free from vibration; (2) the light source, optical system of the microscope, and camera should be capable of centering along a common axis; (3) the plane of the film should be parallel to the object slide; (4) a ground-glass plate should be available for critical focusing of the desired image; and (5) the film and ground-glass focusing plate should lie in the same plane.

In addition to these requirements, the following conveniences are desirable, viz., the apparatus should be capable of (1) quick change from ground-glass focusing plate to camera and vice versa, without disturbing the focus; (2) variation of distance from object to focal plane of the film to obtain various desired magnifications of the image to be photographed; and (3) swinging the photographic apparatus clear of the microscope in order to facilitate visual microscopic observation of the object.

Assuming, as in the present case, that a miniature camera is to be adapted and because the camera lens will be removed for the work, the camera should be equipped with a "behind-the-lens" shutter or it should be one to which a shutter may be adapted with the lens removed. A focal plane shutter is the most desirable but is not essential to obtain good results.

(2) Description of Present Design

Although the present design was intended for the adaptation of the model C2 Argus miniature camera, it can be suitably modified in detail so that other miniature cameras may be adapted to the same type of work.

An assembly drawing of the principal component parts is reproduced in Fig. 1. For this particular design, all parts were made from brass. Optical black, metal paint was applied inside and outside to prevent the possibility of secondary reflections disturbing the clarity and detail of the image to be photographed.

The ground-glass focusing plate was prepared from a lantern-slide cover glass cut to fit the recess in the top of part *C*. The ground glass was masked with optical black paint (as shown in Fig. 1) so that only a rectangular space, equivalent to the dimensions of a 35-mm. film frame, was visible as a ground-glass surface.

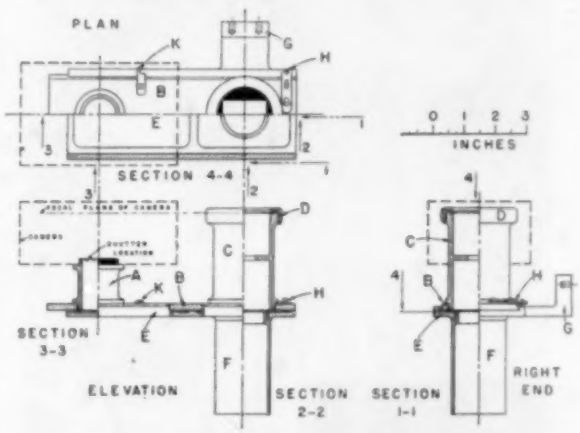

Fig. 1.—Assembly drawing of apparatus.

When it is used for photomicrography, the camera with lens removed is attached to the top of tube *A* (refer to Fig. 1) which is seated on the sliding plate, *B*. The ground glass is fixed in the proper position at the top of tube *C* by engaging part *D*. This focusing tube assembly is seated on sliding plate *B* at the opposite

* Presented at the Forty-First Annual Meeting, American Ceramic Society, Chicago, Ill., April 19, 1939 (Refractories Division). Received April 19, 1939.

end from the previously described camera assembly. Plate *B* is free to slide back and forth easily along the V-shaped track in member *E*. At one end of member *E*, the tube *F*, which fits around the microscope body tube with slight clearance, is attached. The complete assembly of Fig. 1 is bolted to a rotatable arm by means of bracket *G*. The rotatable arm is also capable of translation in a vertical direction along a fixed upright, which is rigidly attached to a heavy, metal base plate on which the microscope rests.

It is clear that quick change from focusing to exposing position may be obtained simply by sliding plate *B* from stop *H* engaged to stop *K* engaged. Without further explanation, it is also clear that the essential and desirable features previously discussed have been fulfilled.

III. Examples of Application

All work to date has been done with Agfa Superpan Supreme negative film, Agfa reversible film transparencies, Dufaycolor film transparencies, and Kodachrome color-film transparencies. Excellent results have been obtained for a wide variety of thin sections. A few of these are reproduced in Figs. 2 and 3 to show the character of the results obtained. Data are given for each photomicrograph, all negatives having been made on Agfa Superpan Supreme film at an image magnification of 50× on the ground-glass focusing plate. All print reproductions appearing in this paper have been enlarged to 160×. All negatives were developed for 10 minutes in Agfa No. 17 borax developer, fixed, and washed in the usual manner.

FIG. 2.

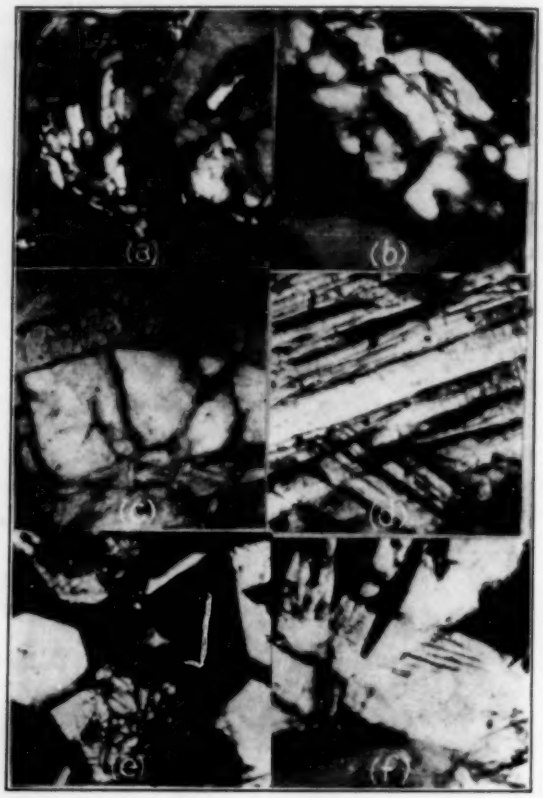

FIG. 3.

(1) Description of Photomicrographs

Figure 2(*a*): *optical system*, crossed Nicols, with sensitive tint plate; *exposure time*, $^1/_5$ second; *description of field*, glass batch stone of quartz, resembling footprint; tridymite radiates out into glass at rim of stone.

Figure 2(*b*): *optical system*, crossed Nicols, with sensitive tint plate; *exposure time*, $^1/_{10}$ second; *description of field*, different portion of same section as (*a*), showing almost complete conversion of quartz to tridymite and crystallization of tridymite from silica-rich glass in the vicinity of stone.

Figure 2(*c*): *optical system*, crossed Nicols, with sensitive tint plate; *exposure time*, $^1/_{10}$ second; *description of field*, different portion of same section as that of (*a*) and (*b*), showing cristobalite formed by devitrification of silica-rich glass resulting from the solution of the quartz.

Figure 2(*d*): *optical system*, crossed Nicols, with sensitive tint plate; *exposure time*, $^1/_{10}$ second; *description of field*, section of "silicicle" from roof of glass tank, showing high-temperature reaction between

alkaline vapors and dusts from the batch on the silica refractory in the roof; large lath-shaped crystals of tridymite have developed from the liquid phase formed from the reaction.

Figure 2(*e*): *optical system*, Nicols at 20°, with sensitive tint plate; *exposure time*, 1/10 second; *description of field*, devitrification stone in glass; the stone is "devitrite" ($Na_2O \cdot 3CaO \cdot 6SiO_2$) and shows the radiating, feathery habit.

Figure 2(*f*): *optical system*, crossed Nicols, with sensitive tint plate; *exposure time*, 1/10 second; *description of field*, elongated, lath-shaped devitrification stones of wollastonite in window glass; skeletal growths of tridymite are also visible.

Figure 3(*a*): *optical system*, crossed Nicols, with sensitive tint plate; *exposure time*, 1/8 second; *description of field*, reaction layer on thermocouple protecting tube above glass melt, illustrating the effect of alkaline vapors on alumina-silica bodies at high temperature; the reaction layer is composed of corundum crystals and interstitial soda-alumina-silica glass.

Figure 3(*b*): *optical system*, crossed Nicols, with sensitive tint plate; *exposure time*, 1/8 second; *description of field*, reaction layer on alumina-silica refractory above glass line in melting end of glass-tank furnace; corundum crystals and interstitial glass are visible.

Figure 3(*c*): *optical system*, crossed Nicols, with sensitive tint plate; *exposure time*, 1/10 second; *description of field*, section of scum on surface of glass in melting end of tank, showing a quartz grain in process of solution. Grain is almost circularized and shows prominent band of cristobalite or tridymite surrounding the periphery of the grain. Numerous "shatter cracks" through the grain are visible.

Figure 3(*d*): *optical system*, Nicols at 15°, with sensitive tint plate; *exposure time*, 1/8 second; *description of field*, section of an experimental electrically fused alumina-silica composition, largely mullite and interstitial glass.

Figure 3(*e*): *optical system*, Nicols at 15°, with sensitive tint plate; *exposure time*, 1/8 second; *description of field*, electrically fused alumina-silica composition having a high alumina-to-silica ratio; crystalline phase is largely corundum; dark interstitial glass with dendritic titania is also present.

Figure 3(*f*): *optical system*, crossed Nicols, with sensitive tint plate; *exposure time*, 1/8 second; *description of field*, electrically fused alumina-silica composition; largely mullite with dark interstitial glass; some corundum is present, though not visible in this field.

IV. Summary

The general requirements of apparatus suitable for microscopic photography have been discussed, and a particular design, fulfilling the essential requirements and desirable features, has been described and illustrated. Typical examples of application to ceramic technology have been given.

Acknowledgment

The writer desires to acknowledge assistance derived from many interesting talks and discussions on photography with Karl J. Belser. Charles Bodell, of the Virginia Polytechnic Institute machine shop, is due a full measure of thanks for his painstaking care in machining the metal parts of the designed apparatus. The assistance of T. C. Vaughan in the preparation of certain thin sections and in making photomicrographs is also gratefully acknowledged. The writer is indebted to Woldemar Weyl and G. S. Fulcher for some of the specimens from which the sections were prepared.

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DRYING CERAMIC PRODUCTS USING INDUCED ULTRA-HIGH FREQUENCY ELECTRICAL ENERGY*

By T. C. Vaughan, H. E. Revercomb, W. A. Murray, and J. W. Whittemore

Abstract

An apparatus was designed whereby samples of plastic clay could be dried by induced ultra-high frequency electrical energy. Clays were dried by this method, and comparisons were made with drying under controlled relative humidity and heated air. Possible practical applications of this method of drying for ceramic plants are noted.

I. Introduction

In drying ceramic products, it is desirable to remove the moisture as rapidly as possible without endangering the structure by uneven shrinkage.

The principal method of drying clay products at the present time consists of passing hot, humid air over the damp clay pieces. Both the humidity and the temperature of the air in contact with the clayware must be accurately controlled to prevent any drying action at the surfaces of the clay pieces before their interiors become heated. If the outside layer of any individual piece dries before all of the water has been expelled from its interior, stresses will be set up, and as a consequence the piece tends to crack or warp. The dry layer at the surface of the piece in addition tends to retard the further passage of moisture from the center to the outside.

The ideal condition for drying clayware is to heat the piece at its center first and to keep the center at a

*Presented at the Forty-First Annual Meeting, American Ceramic Society, Chicago, Ill., April 18, 1939 (Refractories Division). Received April 18, 1939.

higher temperature than the material toward the outside. This condition will produce a high vapor pressure within the piece which will cause forced diffusion of the moisture to the surface, replacing the moisture as it is evaporated from the surface.

It is difficult to obtain this ideal condition with conventional methods of drying ceramic products. This investigation therefore was conducted to determine the possibility of drying by heating ware, from the center first, with ultra-high frequency induced electrical energy.

II. Material

One clay was used throughout this investigation. It was a fine-grained, alluvial-type clay with a high drying shrinkage and a strong tendency to laminate when formed by the auger extrusion method. These properties tended to produce specimens difficult to dry.

III. Equipment

A laboratory drier was constructed, similar to that described by Norton[1] in which the temperature, humidity, and velocity of the air could be controlled. Figure 1 shows *F,M*, a direct-driven fan with which the velocity of air passing from the right-hand to the left-hand compartment is controlled. Heat is supplied to the moving air by resistance wire coils *C,C*. The relative humidity is controlled by the introduction of steam at point S_1, located directly above the resistance wire coils.

The sample is suspended on a glass rod support from balance *B* placed on the top of the drier. A dial micrometer is placed between the point of suspension of the glass support and the sample so that the linear shrinkage of the piece may be obtained at definite intervals throughout the drying period.

The arrows of Fig. 1 show the direction of air travel from fan *F*, located below the right-hand compartment. Air passes through heating coils *C,C* and over the top of the partition, which separates the two compartments of the drier. As shown by the arrows, the air then passes over the wet- and dry-bulb thermometers, *W* and *D*, around the test specimen and through the hole in the floor back to the fan.

Plate electrodes *P,P* are placed on each side of the position for sample *S*. Ultra-high frequency electric current is induced in the sample by these electrodes.

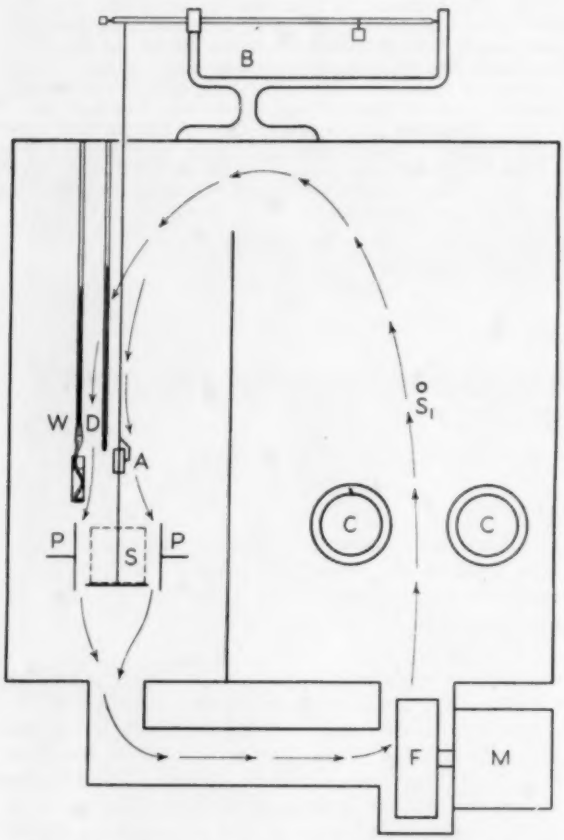

FIG. 1.—Diagrammatic sketch of experimental drier.

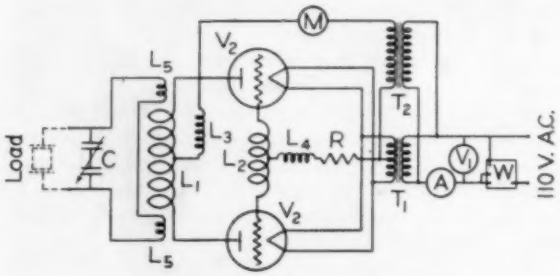

FIG. 2.—Circuit diagram of oscillator.

A push-pull type oscillator is used for the source of high-frequency potential between the plates. Figure 2 shows the oscillator circuit, input meters, and load, described as follows:

- L_1 = plate tank, 1/4-in. copper tubing; 4 turns 3 1/2 in. diameter, 3 1/4 in. long.
- L_2 = grid tank, 1/8-in. copper tubing; 4 turns 1 1/2 in. diameter, 4 in. long.
- L_3 = load coils, 1/4-in. copper tubing; each coil 3 turns 1 1/2 in. diameter, 1 1/2 in. long.
- L_5 and L_4 = choke coils, No. 14 copper wire; 38 turns 1/2 in. diameter, 2 3/4 in. long.
- R = 5000 ohms, 50 ma.
- C = 48 m. m. f. variable condenser.
- T_1 = 110 to 10 volts, 10 amp.
- T_2 = 110 to 2300 volts, 0.5 amp.
- M = 500 ma. d.c. plate meter.
- A = 10 amp. a.c. input ammeter.
- W = 500/1000 input a.c. wattmeter.
- V_1 = 150-volt a.c. input voltmeter.
- V_2 = three electrode vacuum tubes; rating of each tube: plate potential (r.m.s.) (a.c.), 2500 volts; plate current (d.c.), 0.200 amp.; plate input, 550 watts; plate dissipation, 150 watts; grid potential (d.c.), −500 volts; grid current (d.c.), 0.060 amp.; grid current (r.f.), 8.0 amp.; and grid potential (r.f.), 750 volts.

[1] F. H. Norton, "Some Notes on the Nature of Clay, II," *Jour. Amer. Ceram. Soc.*, **16** [2] 86–92 (1933).

The advantage of this type of circuit lies in the fact that alternating current is used for the plate supply. Practically any voltage may be obtained by a simple transformer, whereas high-voltage direct current is difficult to obtain. The tubes used in this oscillator are of the three-electrode vacuum type designed especially for electrotherapy work.

The output frequency is determined by the load, the circuit constants, and the interelectrode capacitances of the tubes. The heating effect due to eddy currents varies directly as the square of the frequency,[2] which was approximately 43 megacycles. The heating effect due to resistance of the clay is independent of frequency and varies as the square of the current.[3]

IV. Procedure

The test specimens, $2^1/_4$-inch cubes, were formed by an auger extrusion machine. As nearly as possible, the same percentage of water of plasticity was used in making up all of the test specimens.

Each specimen was introduced into the humidity drier between the two high-frequency electrodes so that heat could be applied either (1) by induced eddy currents, (2) by preheated, humid air, or (3) by combinations of the two.

Tests were made by using (1) high frequency as the only means of heating the specimens, (2) the resistance wire coils as the only source of heat, (3) a combination of the two sources of heat throughout the entire drying period, and (4) a combination of the two sources of heat for the first thirty-six minutes and the heating coils only for the completion of the drying period. The humidity was controlled throughout in each case, and the fastest drying schedule possible was developed. In the various methods of drying used, many preliminary tests were made to determine the fastest possible rate of drying without damage to the test specimens. Three test specimens were dried by each method.

The linear shrinkage at two-minute intervals was recorded when ultra-high frequency current was used as the source of heat. Readings were taken at five-minute intervals when the heating coils were used as the only source of heat. The critical period during the drying of any ceramic material occurs while the shrinkage water is being expelled. After the shrinkage has stopped, all danger of cracking is ended, although the material is not thoroughly dry. For this reason, only the shrinkage period was considered in the tests conducted.

The power input for the oscillator and for the heating coils was determined on all of the tests.

After all of the test specimens had been completely dried, compressive strength determinations were made.

To determine the way in which heating takes place within a test specimen, an egg was placed between the electrodes, and the position of the first evidence of cooking was noted. A 2-inch cube was bored with a 1-inch hole and placed in the high-frequency field to determine whether the heat would be evenly distributed throughout the cross section of the piece.

V. Results

The average results of the tests using high frequency are shown in Table I. Table II shows the results obtained when high frequency was used a portion of the time with heating coils and when heating coils were the only source of heat.

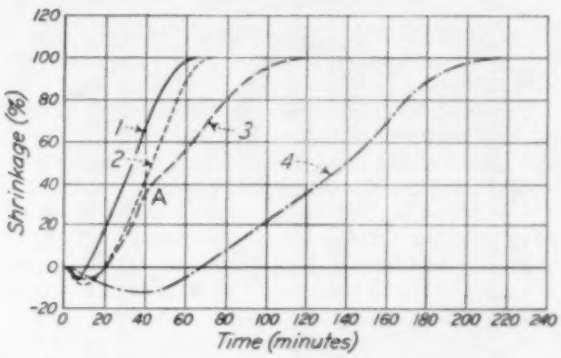

FIG. 3.—Shrinkage rate under various drying methods.

Figure 3 shows the plotted results obtained from the data of Tables I and II. These curves illustrate the relation between the percentage linear shrinkage and time. Curve 1 shows the result obtained by the use of induced, ultra-high frequency electrical energy as the only source of heat. Curve 2 shows the effect of using a combination of high frequency and preheated air to heat the sample. Curve 3 was obtained in a similar manner as curve 2 up to point *A*, where the high-frequency current was cut off and the drying was continued with external heat only. Curve 4 was obtained by the conventional method of drying ceramic products, in which preheated, humid air was passed over the piece.

The averages of the compressive-strength determinations are given in Table III.

The average power input for the method of drying in which ultra-high frequency alone was used proved to be only 26% of the power input required when the resistance heating coils alone were used for the particular drier in which these tests were conducted.

It was definitely proved that the interior of the ware was heated first when introduced into the ultra-high frequency field. With the conventional method of drying by heated air, the outside was heated first. As a test, an egg placed between the electrodes cooked first at its center.

Hollow-ware pieces placed in the high-frequency field are evenly heated through their cross sections, making this type of drying of value for any complicated or intricate shapes.

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[2] H. Pender and W. A. Del Mar, Electrical Engineers' Handbook, Section 3, p. 21. John Wiley & Sons, Inc., 1936.

[3] R. G. Hudson, Engineers' Manual, p. 205. John Wiley & Sons, Inc., 1917.

TABLE I

AVERAGE RESULTS USING (1) ULTRA-HIGH FREQUENCY WITHOUT RESISTANCE HEATING COILS AND (2) WITH RESISTANCE HEATING COILS

Time (minutes)	Linear shrinkage (av. of 3 tests) (1) (%)	(2) (%)
0	0.00	0.00
2	−0.58*	−1.35*
4	−1.90	−4.94
6	−5.40	−7.72
8	−1.73	−8.80
10	2.36	−8.96
12	6.00	−8.69
14	9.66	−7.40
16	13.90	−5.76
18	18.28	−3.75
20	22.65	−0.76
22	26.74	2.39
24	31.40	5.30
26	36.24	8.38
28	40.62	13.04
30	45.58	17.03
32	50.84	21.51
34	56.10	26.10
36	61.36	30.75
38	66.62	35.49
40	71.58	40.47
42	76.39	45.47
44	80.90	50.17
46	84.23	55.13
48	87.71	60.21
50	90.46	65.20
52	93.21	70.04
54	95.52	75.15
56	97.40	79.97
58	98.69	84.25
60	99.85	88.17
62	99.99	91.77
64	100.00	94.55
66		98.22
68		99.10
70		99.63
72		100.00

*Minus signs indicate expansion.

TABLE II

AVERAGE RESULTS OBTAINED WITH (3) COMBINATION OF HIGH-FREQUENCY AND RESISTANCE HEATING COILS FOR FIRST THIRTY-SIX MINUTES AND HEATING COILS ONLY TO COMPLETE TEST AND (4) HEATING COILS ONLY THROUGHOUT TEST

Time (minutes)	(3) Linear shrinkage (av. of 3 tests) (%)	Time (minutes)	(4) Linear shrinkage (av. of 3 tests) (%)
0	0.00	0	0.00
2	−0.37*	5	−0.86*
4	−2.71	10	−4.10
6	−4.57	15	−6.84
8	−5.44	20	−8.77
10	−5.81	25	−10.25
12	−5.69	30	−11.56
14	−5.32	35	−12.25
16	−4.72	40	−12.50
18	−2.95	45	−11.14
20	−0.75	50	−9.23
22	1.63	55	−6.99
24	4.09	60	−4.76
26	7.05	65	−2.16
28	10.10	70	1.33
30	13.51	75	4.63
32	16.82	80	7.50
34	20.21	85	11.16
36	25.77	90	15.11
40	34.71	95	18.23
45	41.24	100	21.79
50	45.78	105	25.35
55	50.21	110	28.66
60	55.36	115	32.09
65	61.34	120	35.52
70	67.97	125	39.09
75	74.42	130	42.60
80	80.26	135	46.01
85	85.60	140	50.01
90	90.10	145	54.04
95	93.46	150	58.46
100	96.10	155	63.79
105	97.95	160	69.68
110	99.29	165	75.37
115	99.88	170	80.57
120	100.00	175	85.28
		180	89.30
		185	92.58
		190	95.04
		195	96.81
		200	98.08
		205	99.01
		210	99.61
		215	99.99
		220	100.00

*Minus signs indicate expansion.

TABLE III

AVERAGE VALUES FOR COMPRESSIVE-STRENGTH DETERMINATIONS

Sample dried by method No.	Compressive strength (lb./sq. in.)
(1)	421
(2)	458
(3)	440
(4)	484

VI. Discussion of Results

(1) Drying with Ultra-High Frequency Electrical Energy as Only Source of Heat

During the first 7 or 8 minutes of the test, the specimen expanded approximately 6%. This was probably caused by the expansion from heating the water film surrounding the clay particles. With this type of drying, there is an abrupt change at the end of 7 or 8 minutes which occurs when the rate of evaporation probably exceeds the expansion of the water film. The relation of shrinkage and time is constant from this point until nearly the end of the shrinkage period. The abrupt slope of this curve is due to the rapid rate of diffusion caused by the heat developed in the interior of the test specimen by the ultra-high frequency current. As the shrinkage ceases, or when practically all of the shrinkage water has been driven off, the curve flattens out.

The time required to complete the shrinkage of the test specimen with this type of drying was about 30% of the time required with the conventional method of drying with heated, humid air.

(2) Drying with Combination of Ultra-High Frequency Electrical Current and External Heating Coils Throughout Entire Shrinkage Period

From curve 2, the change from expansion to contraction within the piece is not as abrupt in this case as when the ultra-high frequency current was used without additional heat supplied from the heating coils. This phenomenon was probably due to the fact that the vapor pressure in the drying chamber was increased by the heat from the resistance coils. This caused the evaporation of water from the surface of the piece to be more difficult than in the first method in which a lower vapor pressure was maintained in the atmosphere surrounding the specimen. The slope of curve 2 after shrinkage began is approximately the same as for curve 1 throughout the remainder of the shrinkage period. This indicates that when the temperature of the interior of the test specimen becomes high enough for the vapor pressure within the piece to overcome the vapor pressure outside, the rate of diffusion becomes equal to that of the first case.

(3) Drying with Combination of Two Methods of Heating for First Thirty-Six Minutes and Heating Coils Alone for Remainder of Shrinkage Period

Inasmuch as the first portion of the drying procedure, illustrated by curve 3, is identical with that of the drying procedure for curve 2, it is expected that they would be similar. At point *A* on this curve, when the ultra-high frequency electrical energy is cut off and the remaining drying of the shrinkage period is completed by means of heated air, the slope of the curve falls abruptly, and the rate of shrinkage is nearly the same as under the conditions of curve 4. Because the time for completion of the shrinkage period under these conditions is approximately one half the time required for the completion of shrinkage under conditions for curve 4, this procedure may be economical for certain types of ceramic products.

(4) Drying with Heat from Resistance Coils

Under the conventional drying conditions used for the tests of curve 4, there is a gradual expansion of the piece during the first forty minutes of the test. Probably little evaporation has taken place prior to this time. It may be noted from the slope of the curve from this point of maximum expansion that evaporation and subsequent shrinkage is going on very slowly for the completion of the test. It was determined from tests that this was the fastest rate possible without damage to the ware, and it is evident therefore that diffusion from the interior to the surface was too slow for any greater rate of shrinkage of the piece. A comparison of this curve with those of the other types of drying shows this method to be slower during every portion of the test.

VII. Conclusions

(1) The time required to dry a test specimen by the use of ultra-high frequency induced current until shrinkage ceases is only 30% of the time required when heat is supplied by resistance wire-heating coils.

(2) It is possible, with the use of the ultra-high frequency energy, to dry complicated shapes evenly over their cross sections, which will enable much more rapid and safe drying of these shapes.

(3) The structures of the pieces are not detrimentally affected by induced current and the rapid drying of this method.

(4) Drying with ultra-high frequency will probably prove to be of economical value for drying complicated shapes when additional research has proved the effectiveness of the use of ultra-high frequency electrical energy.

Further investigations of this study will be conducted at Virginia Polytechnic Institute during the coming year.

Note

The contents of this paper are essentially that of a cooperative thesis prepared by T. C. Vaughan and H. E. Revercomb to meet in part the requirements for the degrees of Master of Science in Ceramic Engineering and Electrical Engineering, respectively, at the Virginia Polytechnic Institute. T. C. Vaughan is Research Fellow, and J. W. Whittemore, Head of the Department of Ceramic Engineering; H. E. Revercomb is Research Fellow, and W. A. Murray, Professor of the Department of Electrical Engineering.

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METHOD OF RECORDING PLASTIC PROPERTIES OF PORCELAIN BODIES*

By L. E. Thiess

Abstract

The plastic working properties of a series of high-tension porcelain bodies have been tested on an apparatus called the Plastograph. An attempt has been made to correlate the data thus obtained with other physical properties, such as grain size, amount of organic (carbonaceous) matter, and dry strength.

I. Introduction

There is a great need for a practical instrument to measure and record automatically the plastic behavior of clay bodies with water. In manufacturing practice, a plastic body, which for a time has given good results, sometimes shows sudden excessive heating-up or laminations in the pug mill. In other instances, the same body may show excessive cracking during the conditioning and drying processes. The defect in the first instance may be due to "shortness" or lowered plasticity; in the second case, the drying cracks may be due to a finer grain size and the resulting increased density of the body. The change in the body apparently may be slight, but because there has been no suitable apparatus available to record the plastic working properties, it has been almost impossible to determine to what degree the faulty body has departed from those bodies which are satisfactory for use.

* Presented at the Forty-First Annual Meeting, American Ceramic Society, Chicago, Ill., April 18, 1939 (White Wares Division). Received March 6, 1939.

II. Apparatus and Tests

The Plastograph has been used to measure the plastic properties of various materials, such as flour (dough), carbon products, clay, rubber, and artificial resins.

Figure 1 gives a detailed description of the apparatus. The small mixer is a pug-mill type, with two sets of paddles turning in opposite directions. The resistance of the material under test to mechanical force, *i.e.*, the torque required to turn the mixing blades at constant speed, is recorded automatically on a chart by means of a curve.

A typical curve is plotted in Fig. 2 from a diagram

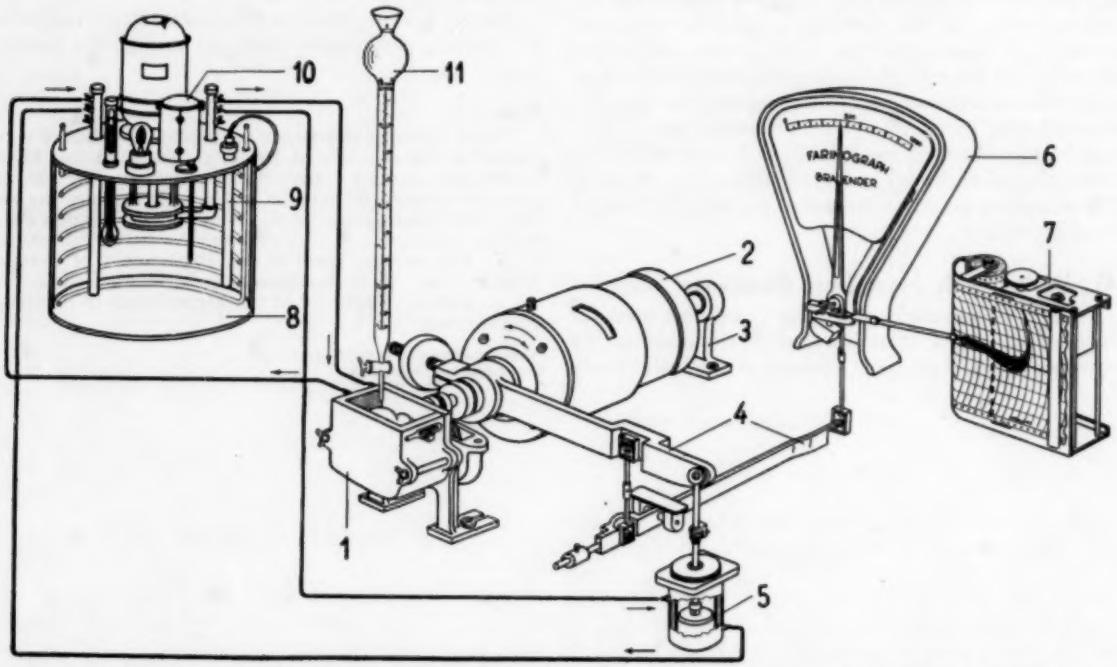

Fig. 1.—The small mixer (1) is driven by a motor (2) which runs freely in ball-bearings (3). The material to be tested offers a certain resistance to the mixer blades and this resistance reacts on the motor. The casing of the motor tends to turn in a direction opposite to that of the driving shaft. These torsion moments are transferred by lever (4) to scale system (6) and are recorded by writing device (7). The oscillations of the lever are damped by the oil-damper (5). The diagram thus obtained, depending on time and temperature, indicates the resistance of the material to mechanical effort. The mixer is provided with a special thermostat arrangement (8). Water is used as a circulating means for temperatures up to 95°C; for other temperatures, other liquids would be used as convenient in the respective cases. The mixer is heated by heating elements if very high temperatures are required for plastographic tests.

for clay with increasing percentages of water. High plastic clays usually give flat curves, while less plastic clays first give a high value at high maximum energy absorption followed by a drop to low values.

Eight bodies were prepared by the usual blunging and filter-pressing. The compositions are shown in Table I. These bodies vary greatly in plasticity, grain size, and dry strength. The dried filter cakes were ground to pass a 20-mesh sieve, and the materials were tested in the Plastograph.

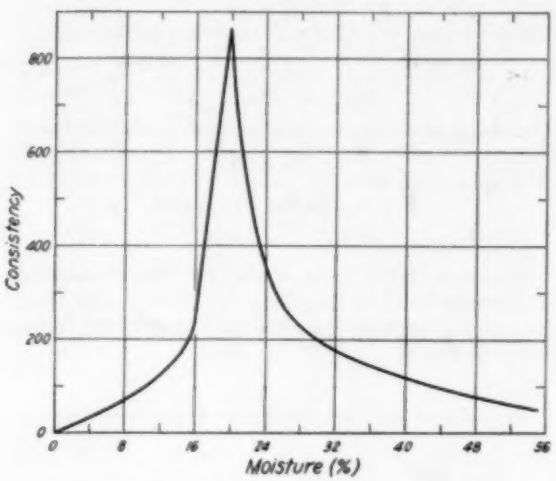

FIG. 2.—Typical plasticity diagram for clays.

A powdered body (400 grams) was put in the mixer and 100 cc. water added; 10 cc. of water were then added every 6 minutes, giving a range of water content from 20 to 32% by weight. The complete run requires 60 minutes. The moisture content for plastic porcelain bodies in the pug mill varies between 20 and 23%.

TABLE I

COMPOSITION OF BODIES AND PHYSICAL PROPERTIES

	Body No.							
Raw materials (%)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
English china clay	50		23	23				
N. C. kaolin							11.5	10.5
Fractionated Ga. clay						50	11.5	10.5
English ball clay								
Light		50	27				27.0	27.0
Black				27	50			
Feldspar	30	30	30	30	30	30	30.0	30.0
Flint	20	20	20	20	20	20	20.0	20.0
Bentonite								2.0
Total	100	100	100	100	100	100	100	100

Body No.	Dry-strength bars (6 x 1 x 1 in.) (lb./in.²)	Carbon* (%)	Grain size (*D*) (<1μ)
1	36	0.04	7.8
2	235	.19	38.0
3	150	.13	27.6
4	261	.49	25.0
5	398	.79	35.0
6	22	.04	7.8
7	234	.16	28.1
8	300	.15	33.0

* Determined by the A.S.T.M. direct combustion method.

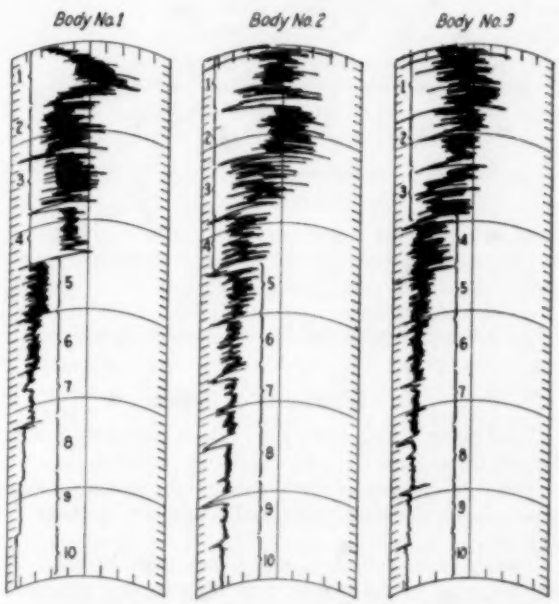

FIG. 3.—Plasticity diagrams: bodies Nos. 1 to 3. The water content for each body is as follows: (1) 20%, (2) 21.6%, (3) 23.1%, (4) 24.5%, (5) 25.9%, (6) 27.3%, (7) 28.6%, (8) 30.0%, (9) 31.0%, (10) 32.2%.

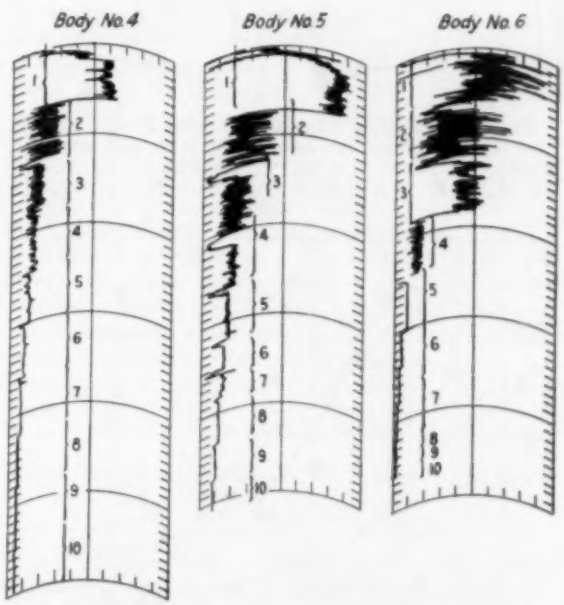

FIG. 4.—Plasticity diagrams: bodies Nos. 4 to 6. The water content for each body is as follows: (1) 20.0%, (2) 21.6%, (3) 23.1%, (4) 24.5%, (5) 25.9%, (6) 27.3%, (7) 28.6%, (8) 30.0%, (9) 31.0%, (10) 32.2%.

The automatically recorded plasticity diagrams (reduced in size) are shown in Figs. 3, 4, and 5, and the curves in Figs. 6 and 7 were plotted from these.

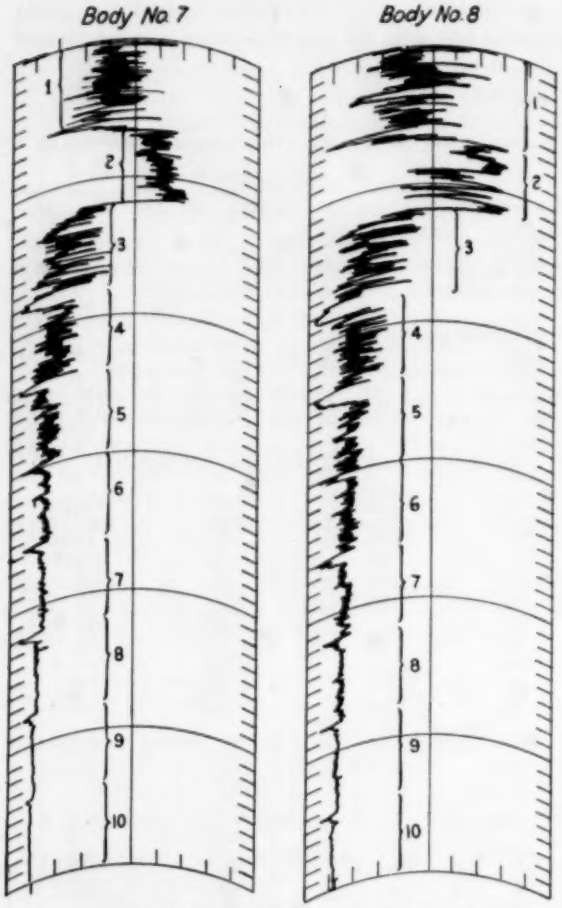

FIG. 5.—Plasticity diagrams: bodies Nos. 7 and 8. The water content for each body is as follows: (1) 20.0%, (2) 21.6%, (3) 23.1%, (4) 24.5%, (5) 25.9%, (6) 27.3%, (7) 28.6%, (8) 30.0%, (9) 31.0%, (10) 32.2%.

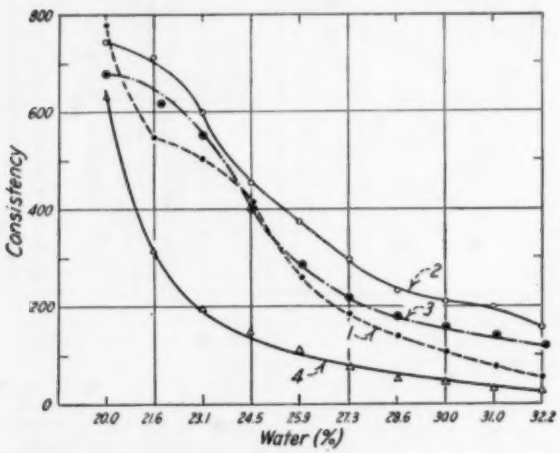

FIG. 6.—Bodies Nos. 1 to 4.

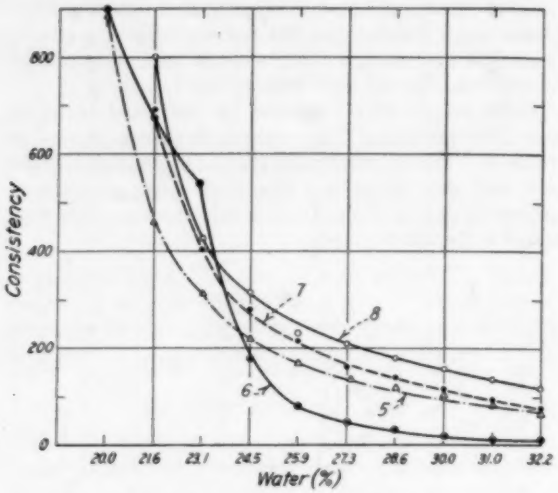

FIG. 7.—Bodies Nos. 5 to 8.

Grain-size tests were made by the Casagrande hydrometer method described by Norton and Speil.[1] The results are shown in the particle-size distribution curves of Fig. 8.

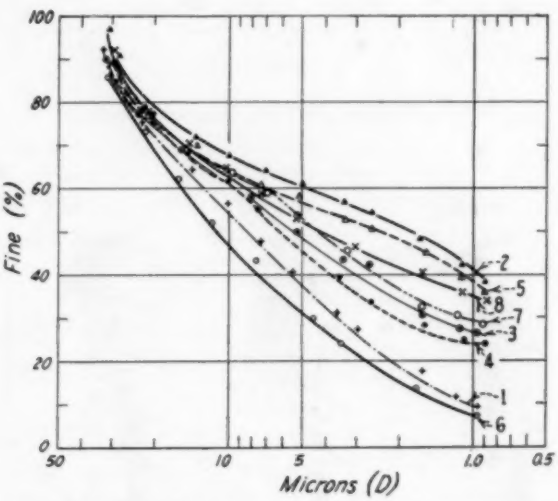

FIG. 8.—Particle-size distribution; bodies Nos. 1 to 8.

III. Discussion of Results

Trial body No. 2, with the highest plasticity value, has the finest grain size and a high dry strength.

Body No. 3, one of the commercial mixtures, has a good plastic working range and a fair dry modulus of rupture.

Bodies Nos. 4 and 5, which are high in colloidal matter, fine in grain size, and high in dry strength,

[1] F. H. Norton and S. Speil, "Measurement of Particle Sizes in Clays," *Jour. Amer. Ceram. Soc.*, **21** [3] 89–97 (1938).

behave somewhat differently in the Plastograph. These bodies show a sharp drop in plastic consistency with only a slight increase in water content, possibly caused by the organic electrolytes in the black ball clay; unfortunately no p_H measurements were made on these bodies.

Bodies Nos. 1 and 6, containing only china clays, show a very low plastic range. The dry strength of these trial bodies is the lowest of the series, and the grain-size distribution curve shows these bodies to be quite coarse.

Bodies Nos. 7 and 8 have a quite similar composition, except that 2% bentonite was added to body No. 8. The effect is shown by an increased plasticity value and a higher percentage of fine grains below 1 micron.

IV. Conclusions

The present investigation is a preliminary study, but interesting results have been found. Studies should be made on the effect of acids and electrolytes upon the plastic properties of such bodies on the Plastograph.

This apparatus may also be helpful to establish some standards for the plastic requirements of wet-process bodies. When substitutions of raw materials or other changes to increase or decrease plasticity are necessary, the Plastograph may furnish valuable guidance.

Note

After the completion of this investigation, a valuable paper was published on the plastic properties of soils which the author wishes to commend to the reader, viz., E. O. Rhodes, "Machine for Testing Highway Subgrade Soils," *Proc. Amer. Soc. Testing Mat.*, **38** [Part II] 551–72 (1938).

Acknowledgment

The author wishes to express his appreciation to A. Hartkopf, manager of the Brabender Corporation, Rochelle Park, N. J. (manufacturers of the Plastograph) for his coöperation in this investigation.

PORCELAIN DEPARTMENT
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SCHENECTADY, NEW YORK

VISCOSITY STUDIES OF DICKITE SUSPENSIONS*

BY A. W. HELZ†

ABSTRACT

Viscosity studies are reported for suspensions of dickite. A horizontal capillary-tube instrument was used to determine the relation between rate of shear and the shearing stress. The effect of oxalic acid, citric acid, tannic acid, and $Na_4P_2O_7$ on the flow properties of dickite in water suspensions is shown. The specific hydrodynamic volumes of dickite in the water suspensions and in glycerine are calculated by the equation, $\eta = \eta_0 (1 + 2.5C + 14.1C^2)$. The resulting values are an indication of the degree of deflocculation. Citric acid has a negligible effect on the specific hydrodynamic volume, and oxalic acid and sodium pyrophosphate decrease it nearly to unity. Oxalic acid and tannic acid give the suspension the property of dilatancy. A brief review of this property and other flow properties of suspensions is included.

I. Introduction

Viscosity studies have been made on suspensions of a clay mineral in order to use such measurements as a criterion of the applicability of Stokes' law to particle-size determinations and particularly to indicate the degree of deflocculation. It is desired to do this kind of work on the mineral components of clays as well as on commercial clays. A fine sample of dickite, which is a constituent of many clays, was obtained for this work. Clay suspensions, furthermore, are good examples of several types of fluid anomalies which have usually been observed on clay mixtures. The observation of the flow properties of a suspension of one of the pure clay minerals therefore is valuable.

There is an ever-increasing demand to know the size distribution of the particles composing clay. Many convenient and widely used methods to obtain such information depend upon the rate of settling of the particles through a liquid. This motion may be caused either by gravity or by centrifugal force. Calculations for these methods are based on Stokes' formula for the resistance of a sphere moving uniformly through a viscous fluid, viz.,

$$F = 6\pi\eta v R. \qquad (1)$$

Where η = viscosity of fluid.
v = velocity of particle.
R = radius of particle.

In deriving this expression, it is assumed that (1) the particles of the suspended material are large compared to the molecules of the fluid; (2) the suspension has infinite extent, *i.e.*, a wall correction is neglected; (3) the particles are rigid and smooth; (4) there is no slipping between the particles and the fluid; and (5)

* Presented at the Forty-First Annual Meeting, American Ceramic Society, Chicago, Ill., April 18, 1939 (Materials and Equipment Division). Received January 24, 1939.

† Edward Orton, Jr., Ceramic Foundation Fellow, Rutgers University, 1936 to 1938.

the particles move with low velocity, *i.e.*, small particles, small difference in density between the particles and the fluid, or high viscosity of the fluid. (For higher velocities and nonspherical particles, Odén[1] gives a modification of Stokes' formula as does Marshall,[2] who also includes a treatment of the effect of hydration.)

In reviewing the literature on methods for determining particle size from the rate of settling, the question of the applicability of Stokes' law is often insufficiently considered. When the method is applied to mixtures of different minerals, the particles may have different shapes, reactions with the liquid, and reactions with the chemicals present in the liquid. Because dispersing and wetting agents are usually used in these determinations, the need for precaution in drawing conclusions is emphasized. On the other hand, the literature reports many experiments in which the determination of particle size by sedimentation methods is in good agreement with values obtained by the microscopic method.

It is important to know more about the condition of the clay particle when it is suspended in water in which both inorganic and organic substances may be dissolved. The effective or hydrodynamic volume (that quantity calculated as volume from an experiment such as the settling rate) is not necessarily the same as the volume of the dry particle. Some of the effects that may produce appreciable differences are (1) solvation, a strong adhering layer of water over the particle,[3] (2) incomplete deflocculation, (3) a charge on the particles, (4) nonspherical shapes, and (5) adsorbed substances on the surface of the particles, especially ions and protective colloids.

The total volume of the dispersed phase may be found from viscosity data. If this is done for the results of Bingham and Durham,[4] a value is found which indicates that the effective size of the clay particles in the suspension used is nine times the size of the dry clay particle. The assumptions upon which this calculation from viscosity data is based are almost identical with those involved in deriving Stokes' formula.

There is a need therefore for additional studies of the hydrodynamic volume of clay and of the effects of the presence of dissolved chemicals on this apparent volume. In such studies, a clay should be used that is a single mineral and of as uniform particle size as possible. Dickite was chosen for the investigation for this reason. Special interest has been directed to the effect of small amounts of tannic acid, citric acid, oxalic acid, and sodium pyrophosphate on the flow properties of dickite suspensions for interpretation in terms of the hydrodynamic volume.

II. Interpretation of Viscosity of Suspensions

(1) Theory of Viscosity of Suspensions

In 1906, Einstein[5] made a rigorous analysis of the viscosity of suspensions. The following simplifying assumptions were made: (1) the dispersed phase is in the form of rigid spheres of uniform size; (2) the mean radii of the particles are small compared to the mean distance between them (this requires dilute suspensions); (3) the mean radii of the spheres are small compared to the smallest dimensions of the shearing liquid (determined by the dimensions of the viscometer); (4) a negligible liquid layer adheres to the particles; and (5) no charge exists on the particles. The resulting expression for the viscosity of a suspension is as follows:

$$\eta = \eta_0 (1 + kC). \qquad (2)$$

η_0 = viscosity of pure liquid.
C = "hydrodynamic volume" of dispersed phase or fraction of volume occupied by dispersed phase.
k = 2.5 for solid spheres as dispersed phase (according to Einstein).

The result is independent of the actual size of the particles as long as these sizes are within the limits set by the assumptions. From time to time, other formulas have been proposed for the viscosity of a suspension, and a thorough survey of this subject has appeared recently.[6] A theoretical discussion is given for the effect of concentration, charged particles, ellipsoidal shapes, and the measuring instruments. If Einstein's assumptions are extended to include higher concentrations, the resulting relation is as follows:

$$\eta = \eta_0 (1 + 2.5C + 14.1C^2). \qquad (3)$$

C = hydrodynamic volume of dispersed phase.

(2) Application of Theory to Experiment

Of particular interest is an experimental verification of the equation by Eirich and Goldschmid,[6(g)] who made a suspension of glass beads to control conditions of sphericity, etc. The Couette viscometer gave viscosity values, showing the expression to be in good

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[1] Sven Odén, "New Method for Measuring Particle Size of a Suspension," *Kolloid-Z.*, **18**, 33 (1916).

[2] C. E. Marshall, "Studies on Degree of Dispersion of Clays: I, Technique and Accuracy of Mechanical Analysis Using the Centrifuge," *Chem. & Ind.*, **50** [49] 444–50 (1931); *Ceram. Abs.*, **11** [3] 208 (1932).

[3] W. W. Meyer, "Colloidal Nature and Related Properties of Clays," *Jour. Research Nat. Bur. Stand.*, **13** [2] 245–58 (1934); R. P. 706; *Ceram. Abs.*, **13** [11] 302 (1934).

[4] E. C. Bingham and T. C. Durham, "Viscosity and Fluidity of Suspensions of Finely Divided Solids in Liquids," *Jour. Chem. Soc.*, **46**, 278–97 (1911).

[5] A. Einstein, "New Determination of Molecular Dimensions," *Ann. phys.*, **19**, 289 (1906); **34**, 591 (1911).

[6] (*a*) E. Guth, "Investigation of Viscosity of Suspensions and Solutions: I, Suspensions," *Kolloid-Z.*, **74** [2] 147–72 (1936); (*b*) W. Krasny-Ergen, "II, Theory of Electroviscosity," *ibid.*, pp. 172–78; (*c*) E. Guth and R. Simha, "III, Viscosity of Globular Suspensions," *ibid.*, [3] 266–75; (*d*) F. Eirich, M. Bunzl, and H. Margaretha, IV, *ibid.*, pp. 276–85; (*e*) E. Guth, "V, Influence of Brownian Movement on Viscosity of Ellipsoid Suspensions," *ibid.*, **75** [1] 15–20 (1936); (*f*) F. Eirich, H. Margaretha, and M. Bunzl, "VI, Viscosity of Acicular Suspensions," *ibid.*, pp. 20–37; *Ceram. Abs.*, **15** [7] 220 (1936); (*g*) F. Eirich and O. Goldschmid, "VIII, Inertia Effects of Suspended Spheres," *Kolloid-Z.*, **81** [1] 7–18 (1937); *Ceram. Abs.*, **17** [8] 285 (1938); (*h*) E. Guth, *Phys. Rev.*, **53**, 322 (1938).

agreement with the facts. A capillary-tube viscometer showed a considerable deviation, and it was thought that turbulent flow might be the cause of the observed difference.

In the present investigation, it is assumed that equation (3) applies. A value for C, the hydrodynamic volume, will be found from the viscosity data and compared with the volume concentration calculated from the weight concentrations and the densities. If these two values for the volume of the suspended clay do not agree, the suspension is considered to be in conflict with the assumptions used in deriving the viscosity expression as well as with Stokes' law; *i.e.*, if Stokes' law is used to calculate R, the value obtained is not the same as the radius of the dry particle but an effective radius of the particle under the conditions of the suspension.

In many of the results, there is no definite viscosity for the suspensions, but there is a variable apparent viscosity. In such cases, comparisons will be made, using apparent viscosities for the same rate of shear or for the same shearing force. To clarify these terms, a brief summary of the flow properties of liquids follows.

III. Flow Properties of Liquids

(1) Newtonian and Non-Newtonian

A liquid is said to be Newtonian (1) when there is laminar flow and (2) when the force between adjacent layers is proportional to the area of contact and the velocity gradient. If dv is the difference in velocity between two parallel layers dz distance apart, the tangential force between them is as follows:

$$F = \eta A \frac{dv}{dz}. \qquad (4)$$

Where A = area of contact.
η = proportionality factor (coefficient of viscosity).

Many liquids do not exhibit this simple relation between the rate of shear, dv/dz, and the shearing stress, F. Figure 1 shows the flow characteristics of several types of materials.

A Newtonian liquid has flow characteristics represented by A; the other types (Fig. 1) are non-Newtonian. Liquid A alone shows a direct proportionality between the rate of shear and shearing stress and consequently a single viscosity value. For the other types, the ratio between the rate of shear and shearing stress will not be constant. This ratio therefore is called the "apparent viscosity." Viscosity is a characteristic constant of a Newtonian liquid, and apparent viscosity (an analogous factor for a non-Newtonian liquid) is a function of the rate of shear.

There are several other types of fluid behavior, not readily represented by a diagram such as Fig. 1 but of much interest, viz., dilatancy, thixotropy, and rheopexy. Properties associated with these three terms are often found in suspensions, i.e., a finely divided solid dispersed in a liquid.

(2) Dilatancy

The property of dilatancy may be observed in clay suspensions or suspensions of finely divided quartz[7] at a rather narrow range of concentration of the solid phase. Such suspensions show a rapid increase in the apparent viscosity with an increase in the rate of shear (Fig. 1, E). Stirring such a suspension produces a peculiar sensation in that it seems to be very fluid if stirred slowly. If an attempt is made to stir it rapidly, the suspension will harden enough to have the characteristics of a stiff paste. Freundlich and Roder[8] discuss this property and give a way to demonstrate it experimentally. They state that "the external force causes an unequal distribution of the particles which are piled up locally, and in other regions cavities are formed which are filled with liquid." This results in a solid network of particles. A correlation of dilatancy with sedimentation volume and the effect of different suspending mediums indicate to these authors that the particles in this type of system are absolutely independent of one another.

(3) Thixotropy

An opposite effect to dilatancy is thixotropy which, according to Freundlich, is an "isothermal reversible decrease of viscosity with shear." An extremely thixotropic substance, upon standing, will form a stiff gel which can be transformed into a liquid with a single mechanical shock. Goodeve and Whitfield[9] have

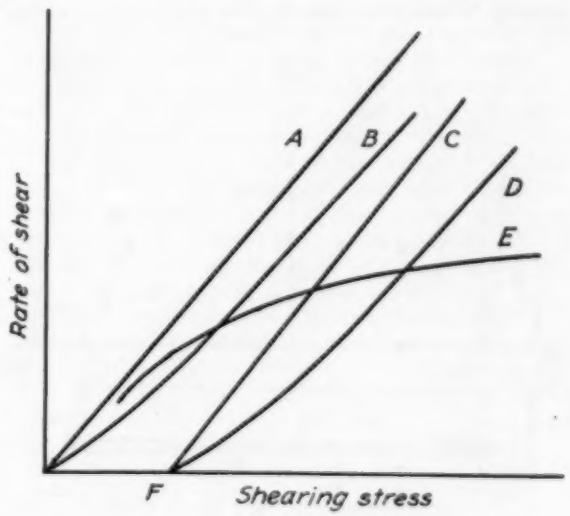

FIG. 1.—Flow characteristics of materials.

[7] H. Freundlich and A. D. Jones, "Sedimentation Volume, Dilatancy, etc.," *Jour. Phys. Chem.*, **40**, 1217–36 (1936).

[8] H. Freundlich and H. L. Roder, "Dilatancy and Its Relation to Thixotropy," *Trans. Faraday Soc.*, **34**, 308–16 (1938).

[9] C. F. Goodeve and C. W. Whitfield, "Measurement of Thixotropy in Absolute Units," *ibid.*, **34**, 511–20 (1938).

proposed a quantitative definition, viz., "the coefficient of thixotropy is the limiting slope of the viscosity-reciprocal shear curve as the shear approaches a high value."

$$\eta - \eta_0 = \frac{\theta}{S}. \qquad (5)$$

Where θ = coefficient of thixotropy.*
S = rate of shear.
η = apparent viscosity of suspension.
η_0 = apparent viscosity for high rate of shear.

* The quantity, θ, is analogous to Bingham's yield value, illustrated by point, F, for system C (Fig. 1).

In thixotropic sols, the dispersed particles seem to have a tendency to adhere or to form some kind of a network. This is the important difference between a thixotropic and a dilatant substance.

(4) Rheopexy

A third property of suspensions, related to dilatancy and thixotropy, is called rheopexy by Freundlich and Juliusburger,[10] who described it as follows: "Thixotropic sols or suspensions containing anisometric particles solidify rapidly in the course of a few seconds as soon as the particles are oriented by gentle movement. The same systems need a much longer time to solidify spontaneously."

IV. Measurement of Apparent Viscosity

It has been stated that suspensions are often non-Newtonian, which makes it necessary to determine the relation between the rate of shear and shearing stress.

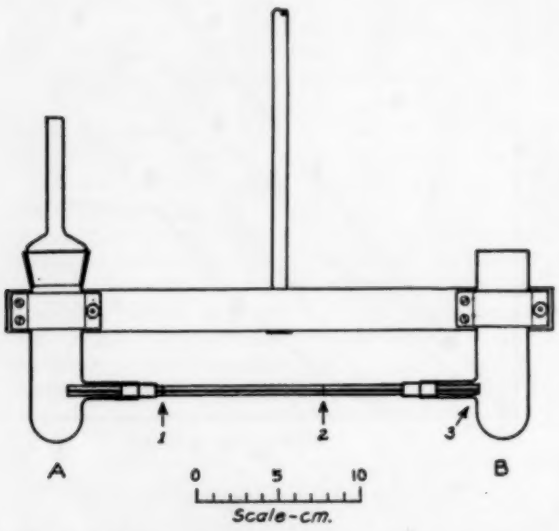

FIG. 2.—Modification of Bingham and Murray apparatus with long horizontal capillary tube.

The instrument to be used in the present work must require only a small amount of the suspension, and there should be facilities for stirring the suspension violently immediately before a run. A modification of the capillary-tube viscometer was chosen as being best suited for the problem. Hall,[11] however, has shown that the results in terms of absolute units of viscosity are subject to question. Although there is this disadvantage, an anomalous flow property of the suspension is brought out.

(1) Description of the Apparatus

The final form of the instrument was a modification of the Bingham and Murray type[12] which employs a long, horizontal capillary tube (Fig. 2). In this method, the suspension is made to flow through the tube under a predetermined pressure head. The time required for the meniscus to pass marks along the length of the tube as the tube fills with the suspension is recorded. The design was made to control the temperature by immersing the instrument in the water of a thermostat to a point 1 cm. above the capillary tube.

Referring to Fig. 2, tube A is connected to the pressure-adjusting system by a ground-glass cap; tube B, which contains the suspension, remains open to allow stirring up to the moment a determination is made. The capillary connecting A and B fits inside the side-arms. The diameters are so adjusted that a tight joint is obtained by a short length of rubber tubing over the capillary which wedges into the slightly conical ends of the side-arms. After a run has been made, the capillary tube is taken out to be cleaned and dried as follows: The cap from tube A is removed; this allows the rest of the instrument to be removed from the thermostat as a unit. It is held and clamped outside the thermostat with end A high enough above B to prevent the liquid in B from running down the capillary or running out of the side-arm when the capillary tube is pulled from B. The cleaned capillary or an interchangeable one is replaced by the reverse procedure. The suspension is kept from entering the capillary tube until a run is started by holding the instrument tilted as described while the ground-glass cap is replaced on A. A little air pressure applied through A holds the suspension back while the instrument is leveled in the thermostat and up to the time a determination is started.

The pressure is measured on a water manometer (observed with a cathotometer) and is maintained constant during a run by including a 5-gallon bottle in the system. Starting at A, the line branches in two and each branch has a stopcock. The volume, including that of A and the tubing, is kept as small as possible. One branch leads through drying bottles and is used to obtain pressures greater than atmospheric. This furnishes a means of control preceding a run. The other branch is connected (after the stopcock) to a water manometer, a 5-gallon bottle, and a vacuum

[10] (*a*) H. Freundlich and F. Juliusburger, "Thixotropy, Influenced by Orientation of Anisotropic Particles," *Trans. Faraday Soc.*, **31**, 920–21 (1935).
(*b*) H. Juliusburger and A. Pirquet, "Thixotropy and Rheopexy of V_2O_5 Sols," *ibid.*, **32**, 445–52 (1936).

[11] F. P. Hall, "Methods for Measuring the Plasticity of Clays," *Bur. Stand. Tech. Paper*, No. 234, p. 345 (1922).

[12] E. C. Bingham, H. A. Murray, Jr., *et al.*, "New Combined Viscometer and Plastometer," *Proc. A.S.T.M.*, **23** [Part II] 655–68 (1923); *Ceram. Abs.*, **3** [6] 204 (1924).

pump. In clamping the viscometer in the thermostat, the capillary is easily leveled by making it parallel with its image in the water surface just above it.

The capillary tubes are always cleaned and dried between successive runs. This is done by (1) forcing water through them under considerable pressure, (2) rinsing with distilled water, and (3) drying by air suction with an aspirator. The air used for drying first passes through a train of wash bottles which removes moisture and dust.

NOTE: Jena K. P. G. precision-bore capillary tubing was used in the viscometer. The two sizes, according to the manufacturer, were 0.050 ± 0.001 cm. and 0.100 ± 0.001 cm. in diameter. These diameters were checked by determining the length and mass of a mercury thread held in several positions along the tube. The values were 0.05008 cm. for the small tubes and 0.10072 cm. for the larger; the lengths of the tubes were sectioned off as shown in Table I.

TABLE I

		Radius (cm.)	
		0.02504	0.05036
Start to 1st mark	l_1	5.23	3.95
1st mark to 2nd	l_2-l_1	10.04	9.97
2nd mark to end	l_3-l_2	10.02	9.92

(2) Calculation of Rate of Shear and Shearing Stress

Rate of shear $= \frac{4\,\Delta l}{r\,\Delta t}$ reciprocal sec.

Shearing stress $= \frac{Pr}{2l}$ dynes/cm.[2]

r = radius of capillary (cm.).
Δl = length of capillary section (cm.).

$l = \left(\frac{l_1 + l_2}{2}\right)$ or $\left(\frac{l_2 + l_3}{2}\right)$ as the case may be.

Where l_1, l_2, l_3 = distance from starting end to end of section in question.

Δt = time (sec.) for meniscus to travel length of section (measured with a $^1/_{10}$-sec. stopwatch having two hands, enabling measurement of two successive intervals).

P = pressure (dynes/cm.[2]).

$$P = (h_1 d_1 + h_2 d_2)g.$$

h_1 and d_1 = height and density of that part of suspension adding to air pressure, measured by h_2 and d_2 of liquid in manometer.

Data in the present investigation are calculated in terms of the rate of shear and the shearing stress. These values are plotted, and the resulting curve is an indication of the kind of flow that is being observed. If a straight line intersecting at the origin is obtained, the slope of the line or the ratio (shearing stress divided by rate of shear) is the viscosity in absolute units (poise). The following conditions of Poiseuille's law of flow through a capillary tube then are probably fulfilled: (1) streamline flow, (2) the liquid is Newtonian, (3) there is no slippage between the wall of the capillary and the liquid, and (4) the flow is slow enough to make the kinetic energy effect negligible. If a plot of the rate of shear and the shearing stress does not produce a straight line intersecting at the origin, the ratio of the shearing stress divided by the rate of shear is "apparent viscosity." The units are the same as for absolute viscosity.

(3) Supplementary Experimental Details

After the viscometer with the suspension in it has been placed in the thermostat and the pressure in the large flask is adjusted, a few minutes are allowed for temperature equilibrium. Then, after vigorously stirring the suspension, the proper stopcock is turned, and the time is measured for the meniscus to go from the first mark to the second mark and from the second mark to the end. Thus one passage of the meniscus through the tube furnishes data for calculating two sets of values of shearing stress and rate of shear. The pressures are determined at the close of a run. By readjusting the pressure, replacing or cleaning the capillary, and repeating as before, two additional sets of values are obtained. In most cases, the suspension was too fluid to take the time accurately in traversing the first section. In these instances, the results may be calculated from the time it takes the meniscus to go from the 5-cm. mark to the end, *i.e.*, a distance of 20 cm.

V. Dickite Suspensions

(1) Dickite

In a search for one of the pure clay minerals, it was found that an ample amount of dickite could be obtained from San Juanito, Chihuahua, Mexico. Ross and Kerr[13] reported on dickite from Chusihuiriachic, Chihuahua, Mexico, as follows: "Compact masses, pure white. The habit is vermicular and the average diameter of the crystals is about 0.03 mm." Some of the physical properties of dickite given by Ross and Kerr are (1) perfect cleavage on the basal plane, (2) a specific gravity of about 2.62, (3) the color in mass white to pale cream or pale green, and (4) the small crystal plates perfectly transparent.

The dickite used in this work was received in the form of rocklike lumps which, upon the addition of water, disintegrated into a dense dilatant putty. A few remaining smaller lumps were easily crushed with a stirring rod, and practically all of the material could be washed through a 325-mesh sieve. Most of the excess water was removed by decantation because the dickite settled out rapidly, leaving a clear supernatant liquid. The dickite was dried by heating at 115°C, and the resulting material was a fluffy, slightly pink powder. It was kept in this form in a sealed glass jar.

(2) Preparation of Dickite Suspensions

Whenever several determinations were needed in which the properties of the dickite suspension were to be as constant as possible, a stock suspension was prepared and allowed to stand at least a week before using. A factor to be considered in deciding upon the procedure to be used was whether or not drying

[13] C. S. Ross and P. F. Kerr, "Kaolin Minerals," *U. S. Geol. Surv. Prof. Paper*, No. 165E, pp. 151–80 (1931); see also *Jour. Amer. Ceram. Soc.*, **13** [3] 151–60 (1930).

a clay suspension, after it has been electrodialyzed, permanently alters its properties.

Procedure: To about 400 grams of dickite, screened and dried, 200 cc. of distilled water were added; the mixture was thoroughly stirred, placed in the dialysis cell, and electrodialyzed for four days; the dickite was then removed and placed in a Pyrex-brand flask, and its density was adjusted by adding distilled water.

The stock solution was always stirred vigorously with a motor-driven glass propeller before a sample was removed. In runs where the addition of a chemical was required, a weighed sample of the stock solution was first placed in a 150-cc. beaker supplied with a stopper. The chemical was added, after which the material was thoroughly stirred. The stirring was repeated a number of times until the start of a determination, which was always more than four hours after the chemical had been added. The suspension in the viscometer was effectively stirred with a long glass stirring rod having a propeller-shaped end.

The suspension, after electrodialysis, had a tendency to settle out less rapidly than before, and the volume of sedimentation was greatly increased. The settled dickite was more readily shaken up than before electrodialysis. The apparent property of dilatancy, which was marked in the unelectrodialyzed material, had vanished. This change in the properties of the dickite suspension depends upon a small amount of soluble substance because only a small quantity of electricity is needed to lower the current to its minimum value.

(3) Chemicals

The citric acid, tannic acid, oxalic acid, and glycerine were Merck's highest quality. The glycerine was carefully redistilled under reduced pressure, and precautions were taken to keep it free of water. A determination of its density gave the value 1.2573 grams per cc. at 25°C; the I.C.T. value is 1.2593.

(4) Size of Dickite Particles

The general appearance of the washed, screened, and dried dickite under the microscope was the same as that described by Ross and Kerr. A particle-size count on this material* revealed the following information (in units of microns):

Size group	No. of particles	Size group	No. of particles
25 x 25	6	8.5 x 17	332
17 x 34	6	8.5 x 8.5	388
17 x 25	22	4 x 5	303
17 x 17	220	Very small	118

Using the pipette rate-of-settling method on (A), a sample of the screened and washed dickite, and on (B), a sample of the screened, washed, and electrodialyzed dickite, the following values, given as percentage by weight greater or smaller (plus or minus) than the indicated diameters, were determined†:

Diameter (μ)	(A) (%)		(B) (%)	
	I	II	I	II
+44	0.3	0.3	0.0	0.0
−20	78.8	76.2	79.6	80.2
−10	36.8	34.5	39.2	39.7
− 5	8.8	6.8	6.9	5.3
− 2	2.8	0.8	2.8	3.2
− 1	2.0	0.8	0.8	1.2

The general conclusions from these data are that the microscopic and rate-of-settling results are in general agreement, most of the material according to mass is in particles approximately 15μ in diameter, there is a negligible amount of extremely fine particles, and electrodialysis does not appear to alter the particle size as determined from the rate of settling.

VI. Results and Discussion

The experimental work is conveniently placed into six groups according to the dickite suspensions considered. The first of these to be reported is a series of suspensions of dickite in glycerine. This group of determinations, however, was not the first to be run. The work on water suspensions indicated anomalous effects which appeared to be a kind of turbulence; a suspending medium which had a much higher viscosity was therefore used. Glycerine was chosen, not only for this reason but also because, like water, it is a polar liquid. Changing the suspending medium from a polar liquid to a nonpolar liquid may entirely alter the nature of the suspension.[8]

In the work with water suspensions, the following studies of the flow properties were made: (1) the effect of the concentration of oxalic acid; (2) the effect of the concentration of citric acid; (3) the effect of the concentration of tannic acid; (4) a comparison of the effect of equivalent amounts of tannic acid, citric acid, oxalic acid, and sodium pyrophosphate; and (5) a comparison of the effect of equivalent amounts of tannic acid and oxalic acid on a dickite suspension of less density than that in the previous four studies.

(1) Density of Dickite

A value of the density of dickite was obtained from one of the stock suspensions which had been electrodialyzed. The suspension was found to have a density of 1.2284; 12.2063 grams of the same suspension, after drying, were found to have 3.6644 grams of dickite. Using the value for the density of water at 25°C as 0.99704, the density of dickite was found to be 2.676 grams per cc.

(2) Dickite in Glycerine

The viscosity of glycerine is sufficiently high to make possible the use of the larger capillary tube (radius 0.05036 cm.). It was also possible to make use of two 10-cm. sections of the length of the tube, *i.e.*, to calculate values for $\frac{Pr}{l_1 + l_2}$ and $\frac{4(l_2 - l_1)}{r\,\Delta t_1}$ and also a set for the latter half of the tube, $\frac{Pr}{l_2 + l_3}$ and $\frac{4(l_3 - l_2)}{r\,\Delta t_2}$.

* Data determined by G. T. Faust, Ceramic Dept., Rutgers University.

† Data from A. Johnson, United Clay Mines Corp., Trenton, N. J.

The dickite used in this series of determinations was washed, screened, and dried as described, but it was not electrodialyzed. Weighed samples were added to 40 grams of glycerine; care was exercised to prevent contaminating the glycerine with water. The mixture was violently stirred upon the addition of the dickite and a few more times during the next four hours. Data were taken at least four hours after the initial mixing. Table II indicates the suspensions considered.

The detailed data of the rate of shear and shearing stress are shown graphically in Fig. 3. The fact that the points fall on straight lines extending through the origin indicates that these suspensions are Newtonian liquids. It is interesting to note that the two sections of the capillary tube give values producing the same straight line as they should. The values for viscosity given in Table II are the slopes of the lines of the plot.

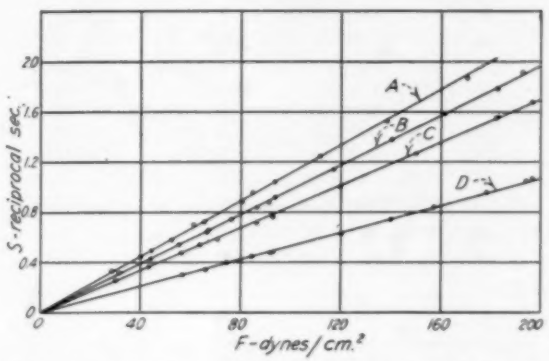

FIG. 3.—Dickite in glycerine; (*A*) pure glycerine.

Dickite suspended in glycerine follows the behavior of clay suspensions in water reported by Bingham.[4] This is shown in the application of his empirical formula,

$$\frac{1}{\eta} = \left(1 - \frac{b}{c}\right)\frac{1}{\eta_0}. \qquad (a)$$

Where η and η_0 have the usual meaning; c = volume concentration for $\frac{1}{\eta}$ equal to zero, found by extrapolating the straight-line relation obtained in a plot of $\frac{1}{\eta}$ against the corresponding values of b, volume concentration of the dickite (Fig. 4).

Thus for a 25.3% volume concentration of dickite, the fluidity $\left(\frac{1}{\eta}\right)$ would be zero; beyond that point, the suspension would no longer be a Newtonian liquid but probably would be type *C* (Fig. 1).

It has been stated that the viscosity of a suspension according to hydrodynamic reasoning is given by

$$\eta = \eta_0 (1 + 2.5C) \text{ for dilute suspensions.} \qquad (b)$$

$$\eta = \eta_0 (1 + 2.5C + 14.1C^2) \text{ for higher concentrations.} \qquad (c)$$

The quantities, b (in Bingham's expression) and C (in the other relations), have the same meaning. In Table III, $v(d)/V$ = volume concentration of solid (determined from densities); $v(a)/V$ = value given by equation (*a*); $v(b)/V$ from equation (*b*) and $v(c)/V$ from equation (*c*). The last three quantities, divided by the value determined from densities, are $v(a)/v(d)$, $v(b)/v(d)$, and $v(c)/v(d)$. These ratios are called the "specific hydrodynamic volume."

Table III shows the results obtained from such a calculation.

The values in column (5) indicate that Bingham's equation successfully correlates the results. It can not be taken to indicate more than this because the constant, $C = 25.3$, which was used to obtain the values, came from the same data. Values of unity for $v(b)/v(d)$ or $v(c)/v(d)$ indicate perfect agreement with the theory (viscosity of a suspension) and experiment. The fact

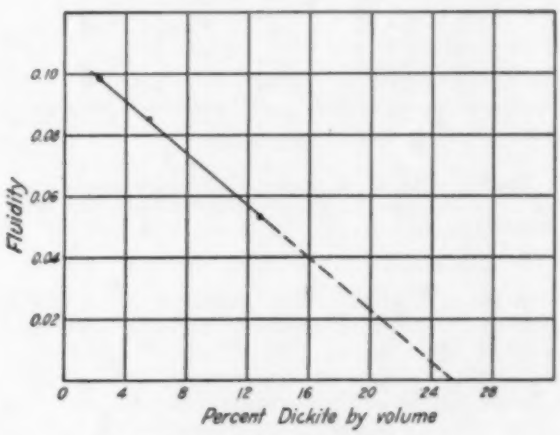

FIG. 4.—Dickite in glycerine.

TABLE II

No.	Dickite added (grams)	Density	η (poises)	v/V (from density)	Dickite by volume (%)	Dickite by weight (%)
1A	None	1.2573	8.94			
1B	2.00	1.2889	10.16	0.0229	2.29	4.76
1C	5.00	1.3330	11.68	0.0555	5.55	11.11
1D	12.50	1.4319	18.59	0.1274	12.74	23.81

TABLE III

No.	(1) $v(d)/V$	(2) $v(a)/V$	(3) $v(b)/V$	(4) $v(c)/V$	(5) $v(a)/v(d)$	(6) $v(b)/v(d)$	(7) $v(c)/v(d)$
1B	0.0229	0.0304	0.0548	0.0440	1.33	2.39	1.92
1C	.0555	.0595	.1224	.0834	1.07	2.21	1.50
1D	.1274	.1312	.432	.202	1.03	3.48	1.58

that the values for $v(c)/v(d)$ are more consistent than those for $v(b)/v(d)$ indicates that the extension of Einstein's equation to an expression for higher concentrations is a definite improvement. If the effect of the shape of the particles is disregarded, it may be concluded that the hydrodynamic volume of dickite is 1.92 (or 1.50 or 1.58, depending on the concentration) times the volume, based on density considerations. This value is considerably smaller than that for the pure material in water. Because of the higher viscosity of the suspending medium, the tendency to impart rotational energy to the particles may be less. The agreement consequently is closer to the theory, which assumes spherical particles that could not attain rotational energy. The lack of agreement may also be traced possibly to a swelling of the particles or an immobilization of the liquid by the particles. These two effects of course would be affected by the nature of the suspending liquid, the particle size of the dispersed phase, and the concentration of the dispersed phase.

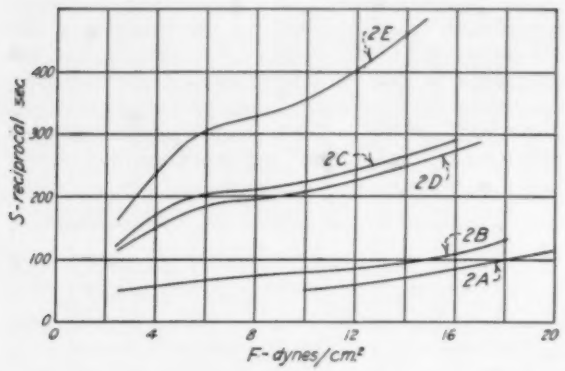

FIG. 5.—Dickite in water; (*A*), pure suspension; (*B*), (*C*), (*D*), and (*E*), increasing amounts of oxalic acid added.

In the work with the water suspensions, the flow is quite rapid, even with the smaller radius (0.02504 cm.) capillary which was used throughout. The time for the meniscus to pass the center mark on the capillary tube was kept, as well as the time to reach the end. All of the following calculations are based on the time to cover the distance from the starting mark to the end, i.e., a length of 20.06 cm. This was done because the time being short for the first section would give inaccurate results. The data, however, on the timing for the two 10-cm. (approx.) lengths gave interesting qualitative results which will be discussed later.

All of the following results were determined with electrodialyzed dickite.

(3) Dickite-Water Suspension Plus Oxalic Acid

The relation found by adding various amounts of oxalic acid to a dickite suspension with a density of 1.2276 grams per cc. is illustrated in Figs. 5 and 6. Figure 5 illustrates the tabulated values of rate of shear and shearing stress; Fig. 6 shows the apparent viscosities (ratios of shearing stress over rate of shear) in relation to the rate of shear for suspension 2*C*.

The curves for rate of shear, *S*, and shearing stress, *F*, show the same changes in slope that occur at vastly different rates of shear but at nearly the same shearing stress. The plot of apparent viscosities (Fig. 6 is a typical example) shows a sudden increase for widely different rates of shear but at nearly the same shearing stress.

Table IV shows values of "η" for corresponding values of $F = 10$ and $S = 100$ (k = concentration of oxalic acid per cc. of suspension).

It is important to note that this change in apparent viscosity (also seen if the complete curves are placed on the same paper) is greater than the variation in the value of "η" for any one curve.

TABLE IV

No.	k	"η" for $F = 10$	"η" for $S = 100$
2A	None	0.176	0.184
2B	6.1×10^{-6}	0.124	0.145
2C	6.1×10^{-5}	0.042	0.019
2D	5.79×10^{-4}	0.046	(0.015)
2E	2.60×10^{-3}	0.028	(0.012)

The type of flow illustrated here is so anomalous that interpretation in terms of hydrodynamic volume is uncertain; this point, however, will be discussed later.

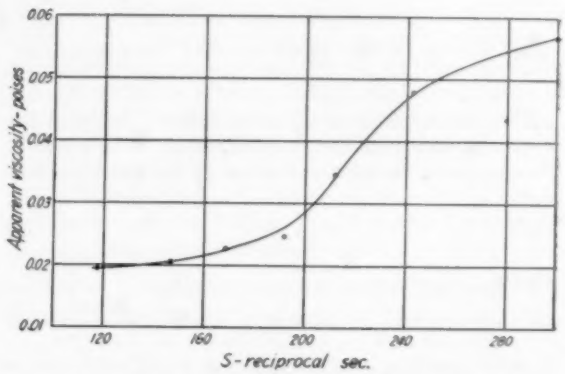

FIG. 6.—Dickite in water with oxalic acid.

(4) Dickite-Water Suspensions Plus Citric Acid

Values of *F*, *S*, and "η" are for a suspension with a density of 1.2274 grams per cc. to which have been added various amounts of citric acid (Figs. 7 and 8). The striking feature here is that the value of "η" is changed little by the addition of citric acid.

The plots, *F*–*S*, are smooth and all are nearly identical (Fig. 7). Figure 8 shows the relation between "η" and *S* for the pure dickite suspension, 3*A*, and two suspensions containing citric acid. The peak in curve 3*A* is not easily reproducible. Check determinations show the same tendency, but the points are much more scattered.

Table V gives values of "η" for arbitrary values of $F = 10$ and $S = 100$; k = grams of citric acid per cc. of suspension.

TABLE V

No.	k	"η" for $F = 10$	"η" for $S = 100$
3A	None	0.152	0.159
3B	4.9×10^{-4}	0.130	0.135
3C	2.10×10^{-3}	0.145	0.153
3D	6.74×10^{-3}	0.158	0.145

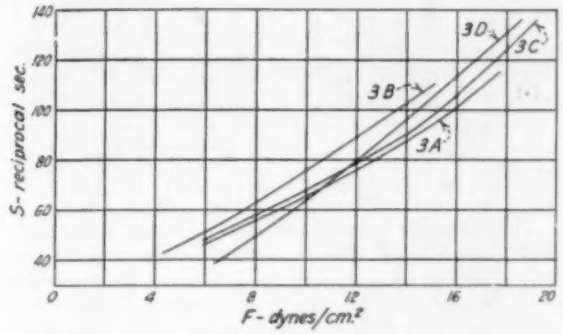

FIG. 7.—Dickite in water with citric acid; (*A*) pure suspension; (*B*), (*C*), and (*D*), increasing amounts of citric acid.

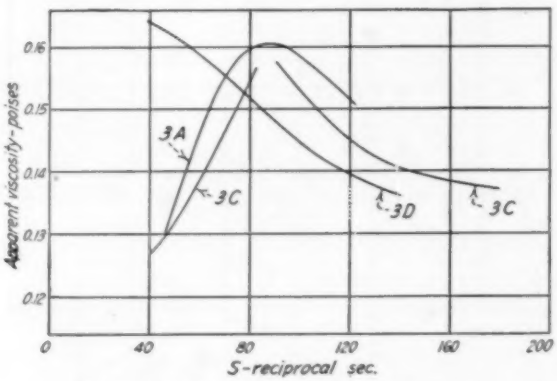

FIG. 8.—Dickite in water with citric acid.

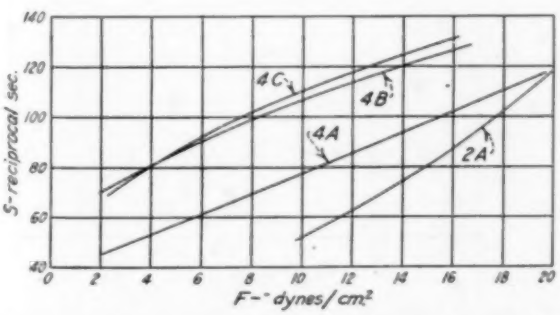

FIG. 9.—Dickite in water; (2*A*), pure suspension; (4*A*), (4*B*), and (4*C*), increasing amounts of tannic acid.

(5) Dickite-Water Suspension Plus Tannic Acid

The plots of the relation, F–S, for dickite suspensions ($D^{25} = 1.2276$) to which various amounts of tannic acid have been added are shown in Fig. 9. The addition of the tannic acid has shifted the curves upward and changed their form from concave (see Fig. 7) to convex, *i.e.*, the rate of shear now tends to reach a maximum value. The "η" plots are smooth regular curves (Fig. 10). Table VI gives values of "η" for arbitrary values of F and S; k is the concentration of tannic acid in grams per cc. of suspension.

TABLE VI

No.	k	"η" for $F = 10$	"η" for $S = 100$
2A	None	0.176	0.184
4A	2.5×10^{-5}	0.131	0.158
4B	5.1×10^{-5}	0.098	0.094
4C	1.02×10^{-4}	0.091	0.074

Tannic acid lowers the apparent viscosity nearly as much as oxalic acid.

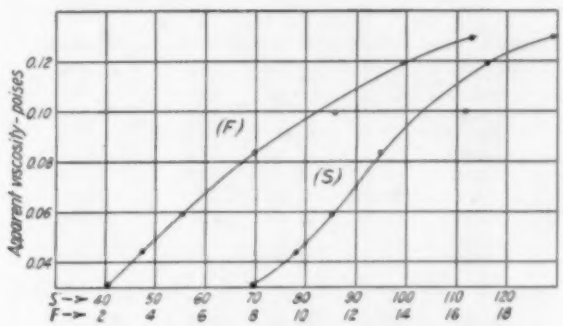

FIG. 10.—Dickite in water with tannic acid.

(6) Equivalent Amounts of Various Chemicals

Table VII gives the complete data on runs using the three organic acids and sodium pyrophosphate; equivalent amounts of each chemical were used. The curves of F and S for the organic acids follow the same general trends as those previously found. The sodium pyrophosphate lowers the viscosity more effectively than do any of the other reagents. Figure 11, combining all of the flow curves, shows how marked is the shift due to sodium pyrophosphate. The curves may be placed into two classes, viz., (A), the pure suspension and those to which sodium pyrophosphate or citric acid have been added which tend to be concave (S increases more rapidly for higher F values) and (B), the tannic acid and oxalic acid which tend to produce a maximum rate of flow. These differences are marked in the general appearance of the suspensions. Suspensions (A) settle out rapidly, leave a clear liquid, produce a relatively small volume of sedimentation (sodium pyrophosphate produces the effects in extreme), and appear to flow through the capillary steadily. Suspensions (B) do not settle out so rapidly, the liquid remains cloudy, and the settled fraction seems to be fluffy. The flow through the capillary tube in this case is unusual

because it has oscillating speeds. This effect is partially shown in Table VIII, which gives the time for the meniscus to cover the first 10-cm. and second 10-cm. sections separately.

It will be noticed that t_1 changes considerably but that t_2 remains almost constant even though the pressure is greatly changed. In some cases, t_2 would first decrease with decreasing P.

TABLE VII

P (dynes/cm.²)	Δt(sec.)	$Pr/2l$	$4\Delta l/r\Delta t$	"η" (poise)
Dickite in water (D^{25} = 1.2274)				
25720	18.6	21.10	172	0.122
22980	22.2	18.85	145	.130
20810	27.0	17.10	119	.144
19110	26.9	15.70	119	.132
17970	30.8	14.74	104	.141
16180	33.1	13.28	96.9	.137
16140	37.0	13.26	86.7	.153
15840	40.3	13.00	79.5	.164
15720	39.4	12.91	81.4	.159
14430	41.4	11.85	77.5	.153
12360	51.6	10.14	62.1	.163
10180	57.6	8.36	55.7	.150
7690	76.8	6.31	41.8	.151
Dickite in water (D^{25} = 1.2274) + 6.55 × 10^{-4} g. oxalic acid/cc.				
19120	10.6	15.70	302	0.0518
16860	12.3	13.83	261	.0530
14490	12.7	11.89	252	.0470
12690	13.6	10.41	236	.0441
10040	14.3	8.25	224	.0367
8700	15.3	7.14	209	.0341
6850	16.8	5.62	191	.0294
5620	17.4	4.62	184	.0250
4380	20.1	3.60	160	.0224
2820	24.5	2.31	131	.0176
Dickite in water (D^{25} = 1.2274) + 1.10 × 10^{-3} g. citric acid/cc.				
27890	16.1	22.88	199	0.115
25480	19.0	20.92	169	.124
23270	20.8	19.12	154	.124
21240	18.8	17.45	171	.102
20940	24.2	17.18	133	.129
20710	24.2	17.00	133	.128
17230	26.9	14.16	119	.119
15230	34.2	12.50	93.8	.133
13100	38.2	10.76	84.0	.128
10820	49.0	8.89	65.4	.136
8010	63.6	6.58	50.4	.131
5900	71.8	4.84	44.7	.108
4660	79.0	3.82	40.6	.094
Dickite in water (D^{25} = 1.2274) + 1.90 × 10^{-3} g. tannic acid/cc.				
18510	22.8	15.20	141	0 108
15500	23.2	12.72	138	.0921
15420	24.6	12.66	130	.0970
13510	26.7	11.10	120	.0923
12200	26.9	10.02	119	.0840
11520	27.3	9.46	118	.0806
8900	29.3	7.31	109	.0668
7470	32.2	6.13	99.5	.0616
6100	35.5	5.01	90.4	.0555
4610	35.6	3.78	90.1	.0420
2600	41.0	2.13	78.2	.0272
Dickite in water (D^{25} = 1.2274) + 2.32 × 10^{-3} g. sodium pyrophosphate/cc.				
7980	6.9	6.55	460	0.0141
6810	7.8	5.59	410	.0136
5780	8.3	4.74	386	.0123
4400	11.2	3.61	286	.0126
3440	12.2	2.82	263	.0107
2430	13.4	1.99	239	.0083

The marked difference between groups (A) and (B) is also brought out in the relation between "η" and S in Table VII. Group (A) shows changes that are much more rapid and irregular in "η" with S or F than do those suspensions in group (B).

TABLE VIII

Tannic acid			Oxalic acid		
P	t_1	t_2	P	t_1	t_2
18510	4.0	18.8	19120	1.4	9.2
15420	5.0	19.6	16860	2.0	10.3
13510	6.4	20.3	14490	1.4	11.3
11520	7.4	19.9	12690	2.0	11.6
8900	11.0	18.3	10040	2.5	11.8
7470	13.0	19.2	8700	3.5	11.8
6100	15.4	20 1	6850	4.0	12.8
			5620	4.0	13.4
			4380	5.4	14.7
			2820	6.4	18.1

This behavior is much like that found by Freundlich and Roder[8] for a dilatant system of quartz in water. Their method of observing the effect was to determine the speed of a sphere moving through the material as a function of the force pulling the sphere. The cause for the behavior of the dickite-water system may be as follows: For lower rates of shear, the disklike

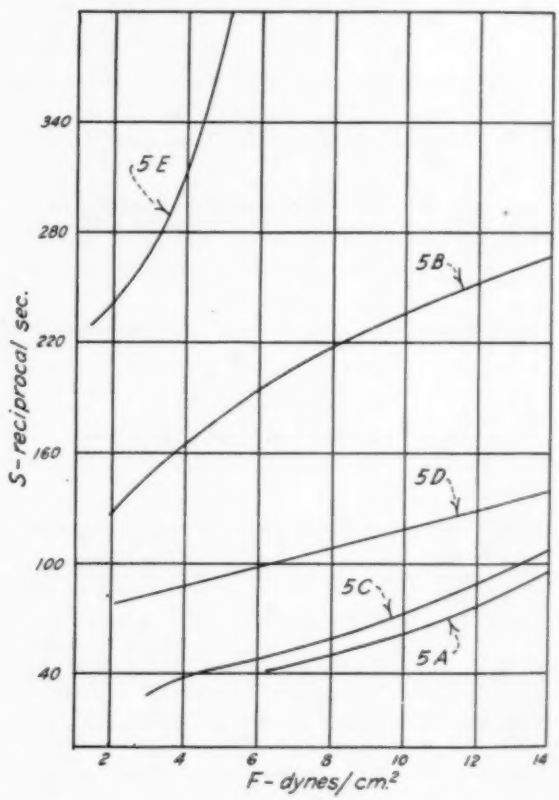

FIG. 11.—Dickite in water; (5*A*), pure suspension; (5*B*), with oxalic acid; (5*C*), with citric acid; (5*D*), with tannic acid; and (5*E*), with sodium pyrophosphate.

particles of dickite can easily flow along edgewise. As the rate of shear increases, the tendency of the particles to rotate increases until a critical speed is reached when they turn in all directions. If the concentration is high enough, this disordered arrangement can produce a blocking effect or, in other words, a great increase in the apparent viscosity. The reverse process should also hold, i.e., as soon as the rate of shear falls below a critical value, the particles line up and allow easy flow through the tube.

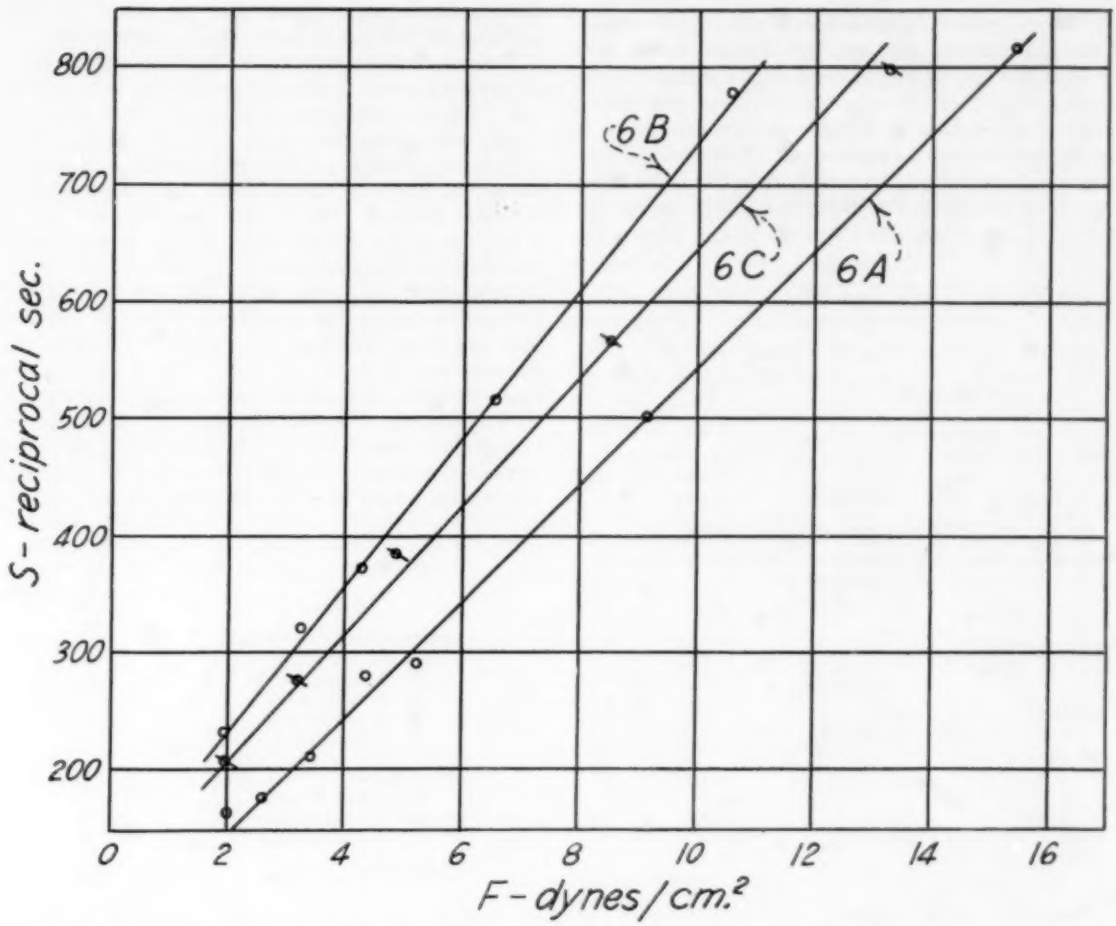

FIG. 12.—Dickite in water; (6*A*), pure suspension; (6*B*), with oxalic acid; and (6*C*), with tannic acid.

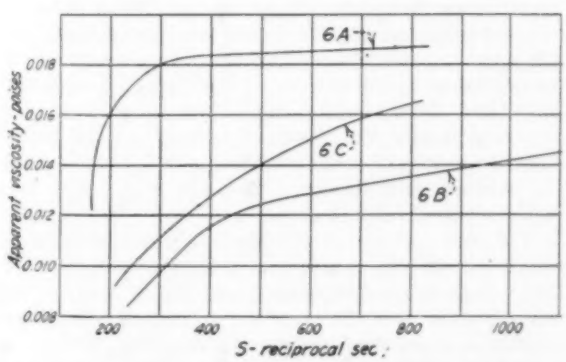

FIG. 13.—Dickite in water; (6*A*), pure suspension; (6*B*), with oxalic acid; and (6*C*), with tannic acid.

(7) Dickite-Water Dilute Suspension

Figures 12 and 13 show how the flow relations of a dickite suspension (density 1.1361 grams per cc.) are changed by the addition of oxalic acid and tannic acid. Figure 12 indicates that for these dilute suspensions there is a closer approach to a Newtonian liquid. Figure 13 shows how the apparent viscosity of these suspensions tend to a maximum for high rates of shear. Typical values (*k* is the concentration of the reagent in grams per cc.) are given in Table IX.

The values of apparent viscosity for low shearing force, especially that of the dickite-oxalic acid system, are practically equal to the viscosity of water (0.00894 accepted value at 25°C), which may be due to a tendency of the particles to settle out.

(8) Hydrodynamic Volume in Water

The fraction of the volume occupied by the solid phase is calculated by solving for C in equation (3) (p. 290). The viscosity of water, η_0, at 25°C is 0.00894 poise; the apparent viscosities of the suspensions are used for η. These values were found by graphical interpolation of the data.

The fraction of the volume on the basis of the volume of the dry material was determined in two ways, viz., (1) from the loss in weight on drying a sample of the suspension and (2) from a graph (previously determined) of the relation between the volume percentage of dry dickite in a suspension and the density of the suspension. The volume percentage of dickite is 13.5% in the suspension when the density is 1.2275 grams per cc. at 25°C and 8.0% when the density is 1.1361. The fractions of the volume occupied by the dickite therefore are 0.135 and 0.080. Dividing the values calculated for C by the appropriate fraction (0.135 or 0.080) results in the "apparent specific hydrodynamic volume." A value of unity obtained for this quantity indicates that the effective volume of the dickite in the suspension is the same as the volume of the dry material. Values greater than unity indicate that the particles are effectively larger in the suspension.

The assumptions involved in an exact interpretation of hydrodynamic volume have already been pointed out. The data presented in this study have shown the dickite-water suspensions to differ from the simple viscous type of liquid. Too much emphasis, therefore, cannot be placed on the following discussion of hydrodynamic volume. The results, however, are a good indication of the general trend and (as was hoped) of the degree of deflocculation.

Table X gives numerous values of specific hydrodynamic volume. Different "run numbers" indicate that the determinations were made on independent preparations of the suspension. Table XI is a summary of the specific hydrodynamic volumes obtained by the addition of equivalent amounts of the various chemicals. Except for the glycerine value, the calculations are values of apparent viscosity corresponding to a shearing force of 10 dynes per sq. cm.

TABLE IX

No.		"η" for $F = 10$	"η" for $S = 800$
6A	None	0.0185	0.0187
6B	3.69×10^{-4} g. oxalic acid	.0134	.0136
6C	1.10×10^{-3} g. tannic acid	.0156	.0165

TABLE X

SPECIFIC HYDRODYNAMIC VOLUME

(Shearing stresses 10 dynes/cm.^{2} and rate of shear of 100 reciprocal sec.)

	Run No.	$F = 10$	$S = 100$
Pure suspension ($D^{25} = 1.2275$)	2	7.9	8.1
	3	7.2	7.4
	5	7.6	7.0
Suspension ($D^{25} = 1.2275$) with oxalic-acid concentrations			
6.1×10^{-5}	2	6.5	7.1
6.14×10^{-5}	2	3.2	1.5
5.79×10^{-4}	2	3.4	1.1
6.55×10^{-4}	5	3.2	
2.60×10^{-3}	2	2.3	
Suspension ($D^{25} = 1.2275$) with citric-acid concentrations			
4.91×10^{-5}	3	6.6	6.8
1.10×10^{-3}	5	6.8	6.7
2.10×10^{-3}	3	7.1	7.3
6.74×10^{-3}	3	7.4	7.1
Suspension ($D^{25} = 1.2275$) with tannic-acid concentrations			
2.54×10^{-5}	4	6.6	7.4
5.08×10^{-5}	4	5.6	5.5
1.02×10^{-4}	4	5.4	4.7
1.90×10^{-3}	5	5.1	4.0
Suspension ($D^{25} = 1.2275$) with 2.32×10^{-3} g./cc. $Na_4P_2O_7$	5	1.1	
			$S = 800$
Suspension ($D^{25} = 1.1361$) Pure suspension		2.5	2.6
3.69×10^{-4} g./cc. oxalic acid		1.4	1.5
1.10×10^{-3} g./cc. tannic acid		2.0	2.2

TABLE XI

Run No.	Specific hydrodynamic volume
Suspension $D^{25} = 1.2275$	
5A dickite (pure)	7.6
5B + oxalic acid	3.2
5C + citric acid	6.8
5D + tannic acid	5.1
5E + $Na_4P_2O_7$	1.1
Suspension $D^{25} = 1.1361$	
6A dickite (pure)	2.5
6B + oxalic acid	1.4
6C + tannic acid	2.0
Dickite in glycerine	1.50

The following conclusions are drawn from these data: (1) the apparent specific hydrodynamic volume is greatest for the pure dickite suspension; (2) the various reagents used lower the specific hydrodynamic volume; (3) that substance which is widely used as a deflocculating agent in particle-size determinations gives a volume value closest to the volume of the dispersed phase as calculated from density determinations. It is also observed from calculations not included in the tables that the values of specific hydrodynamic volume tend to increase with increased shearing stress and also with increased rates of shear.

The decrease in specific hydrodynamic volume is much less for (A), tannic acid and citric acid, than for (B), sodium pyrophosphate and oxalic acid. This classification does not place the reagents in the same groups as those obtained in Part VI (6) (p. 297) by a correlation of the flow diagrams, general appearance of the suspension, and tendency toward dilatancy.

The decrease in the hydrodynamic volume or the apparent viscosity of a suspension caused by the addition of small amounts of various reagents is of fundamental interest. If the particles have points of strong attraction for each other, resulting in cluster formation, the effect would be an abnormally high viscosity owing to immobilization of the liquid. If the added reagent then tends to coat the particles, giving them surfaces more like the properties of the water, this clustering is broken down and results in a decrease in viscosity. This mechanism can represent the facts provided the coating on the particles does not alter the viscosity due to an effectively larger particle. This effect, if it were appreciable, would be much less for large than for small particles.

VII. Conclusions

A suspension of dickite in glycerine behaves like a Newtonian liquid in the concentrations studied and probably up to 25% of dickite by volume. This result is interesting in view of the fact that the particles of dickite are large and disklike in shape.

The apparent viscosity of the water suspensions of dickite is changed quantitatively and qualitatively by the addition of small amounts of various reagents.

Oxalic and tannic acid greatly decrease the viscosity and give resulting suspensions which tend to have a maximum rate of shear in the capillary tube, regardless of the shearing force, i.e., the property of dilatancy has been obtained. Citric acid has little effect on the viscosity of a dickite suspension.

The more dilute suspensions are nearly Newtonian. There is a sudden drop in viscosity for low rates of shear, probably due to a settling out of the particles.

The hydrodynamic volume of the dispersed phase is greatest for a pure dickite-water system. All of the reagents used lower the value; sodium pyrophosphate brings the value down nearly to the true volume. Interpretation, however, is restricted by the fact that the suspensions are not Newtonian. Apparent viscosities for a single value of the shearing force were used as a basis for calculation.

The hydrodynamic volume of dickite in glycerine is much less than the apparent hydrodynamic volume in pure water.

Cluster formation and the breaking up of these clusters by the reagents used can account for the effects observed.

The expression, $\eta = \eta_0(1 + 2.5C + 14.1C^2)$, fits the results much better than $\eta = \eta_0(1 + 2.5C)$.

Viscosity determinations may be used to indicate the degree of deflocculation.

Acknowledgment

This research has been made possible through the establishment of a Fellowship in the Department of Ceramics, Rutgers University, by the Trustees of the Edward Orton, Jr., Ceramic Foundation, Columbus, Ohio. For their many suggestions and coöperation, the author is indebted to G. H. Brown, Director of the Department of Ceramics of Rutgers University, and to G. T. Faust, Chairman of the Dissertation Committee.

GLASS-FRACTURE VELOCITY*

By F. E. Barstow and H. E. Edgerton

Abstract

Using an electric spark lasting less than one-millionth second as a light source, cracks in glass have been successfully photographed during their propagation. A steel ball driven against the glass with a spring initiated fracture and simultaneously actuated an adjustable electrical time-delay circuit, which in turn set off the spark at the required instant. By the use of two sparks, the velocity of propagation of cracks in glass was found to be constant and almost exactly 5040 feet per second—the same velocity found by Schardin and Struth. In general, the tips of the cracks form a nearly perfect circle at any particular instant, though some individual photographs show nonsymmetry.

Everyone knows that glass breaks quickly. It has not been appreciated until recently, however, that cracks in glass grow at a constant velocity of 5000 feet per second, that is, twice as fast as a 0.30-caliber rifle bullet travels. The experiments described here demonstrate that cracks in glass travel at the constant speed mentioned when the glass is broken by a blow of relatively low velocity. This investigation gives the same crack velocity as that found by Schardin and Struth,[1] regardless of the fact that they broke glass with rifle bullets that had a velocity some fifty times greater than the objects used in the present study. Perhaps the velocity of growth of a crack is a fundamental constant of nature. But in any case an understanding of the reasons for such a constant velocity may be of considerable interest to the glass technologists.

The photographs illustrating this article were taken with a spark light-source lasting less than one-millionth second. A sufficient quantity of light was obtained from the discharge of a 0.1-microfared condenser charged to 7000 volts. As shown in the diagrammatic sketch of the apparatus (Fig. 1), the spark cast a shadow of the cracks on a film placed directly behind the glass in which the fracture was intiated by a $^3/_8$-inch steel ball driven against it by a heavy spring. A small hole was cut in the film (note black spot at center of each picture) so that the blow would not be cushioned by the film. Inasmuch as there was a lapse of time between the impact and the appearance of the cracks (roughly, 0.0001 second), a corresponding time delay between the impact and the flashing of the spark was introduced by an adjustable electrical time-delay circuit triggered by an electrical impulse obtained when the spring-driven lower plunger struck the breaking rod attached to the steel ball.

Some idea of the difficulties overcome in arranging a spark to "catch" a crack as it goes from the center to the edge of a 4- by 5-inch glass plate (used in these experiments) is gained when the time required for the crack to cross the plate is calculated. A crack goes $2^1/_2$ inches (the distance to the farthest side of a 4- by 5-inch plate) in $^1/_{24,000}$ second, or 41.5 microseconds. The

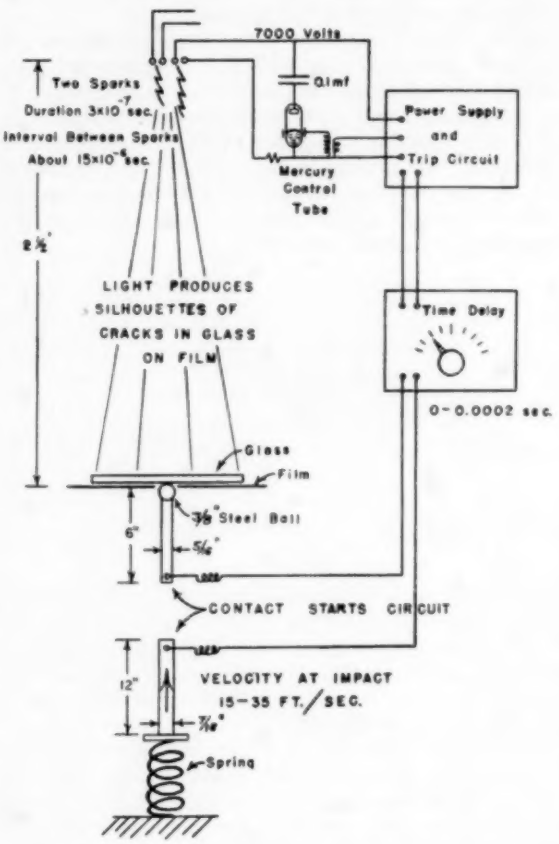

Fig. 1.—Elementary diagram showing the mechanical and electrical arrangement for photographing cracks in glass during fracture following a blow. The spring-driven hammer at the bottom starts the adjustable time-delay circuit when it contacts the breaking rod that drives the steel ball. All of the pictures accompanying this article were taken with a single spark (except Fig. 5, for which a second spark was flashed approximately 15 microseconds after the first spark to determine the velocity of the cracks in this sample of glass).

* Presented at the Forty-First Annual Meeting, American Ceramic Society, Chicago, Ill., April 18, 1939 (Glass Division). Received March 31, 1939.

[1] H. Schardin and W. Struth, "Hochfrequenzkinematographische Untersuchung der Bruchvorgänge im Glas," *Glastech. Ber.*, **16** [7] 219–31 (1938); *Ceram. Abs.*, **18** [1] 17 (1939).

timing of the flash of light, therefore, must be controlled to less than 41.5 microseconds just to photograph the leading edge on the film. An accuracy of about ±5 to 10 microseconds is realized by the apparatus, and therefore little difficulty is encountered in timing. The breaks in the glass occurred with surprising consistency for this investigation.

The accompanying photographs with their captions in general are self-explanatory. It should be emphasized, however, that each photograph is of a *different* piece of glass and therefore no individual crack can be traced from one member of a series to the next except in the case of the double exposures for determining velocities. That the crack patterns are symmetrical about the center is the result of applying a normal load at a point and of the constant velocity of the cracks. The detail at the center is due to the forming of a percussion cone as shown in Figs. 12 to 16.

Several factors tend to indicate that cracks are not started by the initial elastic wave which travels up the rod to the glass (in the case of the examples studied at M.I.T.) but rather by the relatively slowly increasing stresses owing to the geometric distortion of the sample resulting from the blow. Among these factors are the time delay between impact and the appearance of cracks, the perceptible bending seen in the side-view series of photographs, and the appearance of crack origins away from the center *any time* after impact.

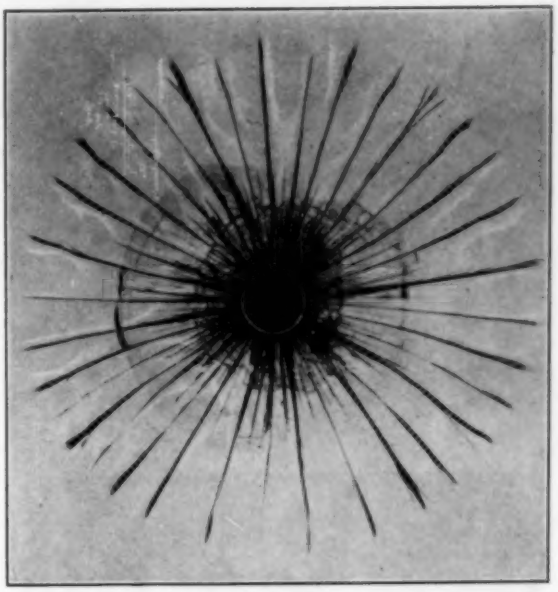

FIG. 3.

FIG. 2

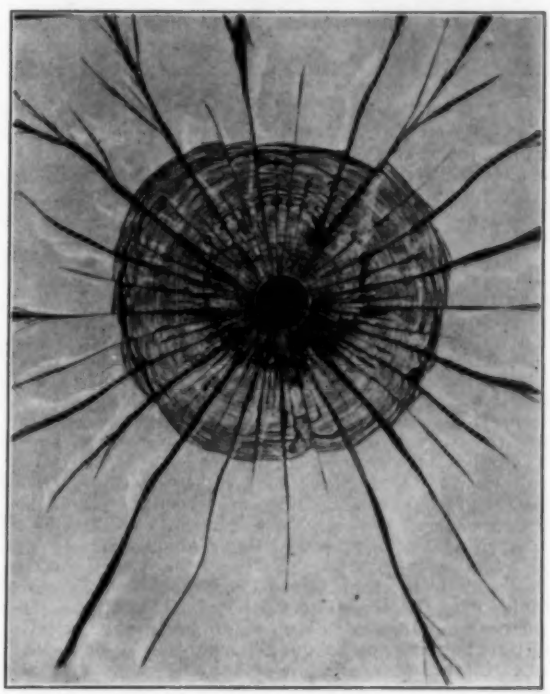

FIG. 4.

Figs. 2, 3, AND 4.—These photographs show the typical development of cracks encountered in annealed plate glass when struck by a blow such as that used in these experiments. The edges of the 4- by 5-inch glass samples as well as the hole in the film (central black spot) may easily be seen. Perhaps the first and most noteworthy observation in these and the other photographs is the circular boundary of the tips of the cracks, indicating that all these cracks travel with the same velocity regardless of direction or position.

Figure 4 was taken so late that most of the cracks had reached the sides or had stopped. Close inspection shows a slight "blur" at the tips of the cracks, due to an "afterglow" of the spark. If no "blur" is present, the cracks may be assumed to be stationary or "dead," which is the case for the shorter cracks in Fig. 4. The development of a percussion cone causes the detail at the center. As the cracks approach the sides of the glass, branching or subdividing of the fractures occurs. The lighter cloudlike wisps running more or less parallel to the cracks are not due to strains but rather to light reflected from the curved surfaces of the cracks.

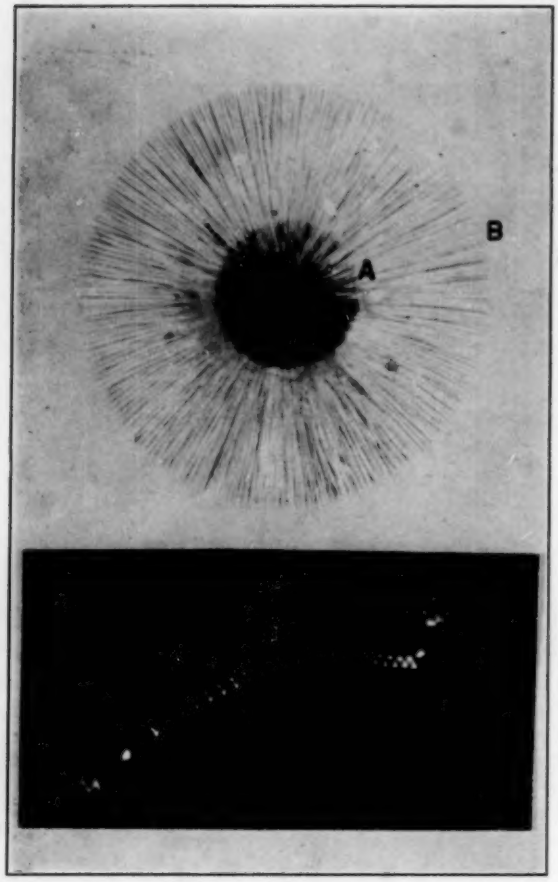

FIG. 5.—This photograph shows the method of determining the velocity of the cracks which was found to be about 5000 feet per second both for annealed and tempered plates. The values obtained from seven samples varied only 1% from their mean and agreed almost as well with those of Schardin and Struth. These determinations, furthermore, were made both near the center and near the edges of the plates. It is interesting to note that this velocity is approximately one third the velocity of sound in glass. As indicated in Fig. 1, two sparks were set off a short interval apart, giving rise to the double-exposure photograph above. The cracks formed the darker section at the center when the first spark was flashed (marked *A*), but had progressed to form the largest circle (marked *B*) a moment later when the second spark was set off. Impulses obtained from these sparks were introduced to a special high-voltage cathode-ray tube to give the two sharp vertical rises seen on the oscillogram. The interval of time between sparks was found by counting the oscillations of a superposed timing wave (2,156,000 cycles per second) between the two sharp rises. The velocity then was the difference in the radii of the two superposed exposures divided by the time interval between the sparks. In this way one does not depend upon an average interval of time between sparks, but the true value to be applied to each crack photograph is determined.

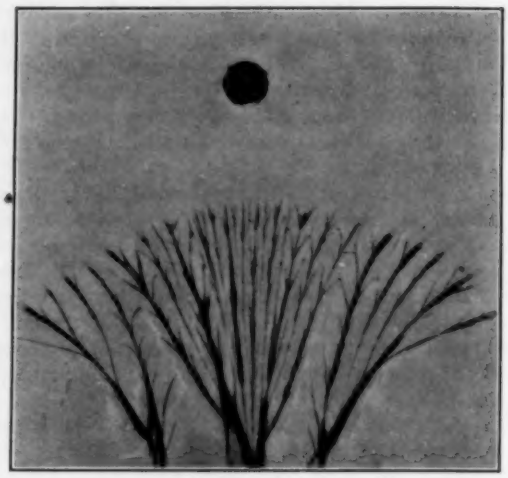

FIG. 6.—Although conditions supposedly were the same, about one quarter of the samples showed some unusual behavior of the cracks (this photograph being an example). Though the glass was struck in the middle, the binding forces apparently were exceeded sooner at the edge than at the center. Whether one, two, or three origins occur, they are nearly always placed symmetrically about the center of a side. Other photographs also show that cracks may proceed simultaneously both from the center and from any side.

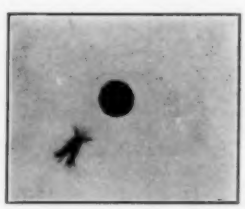

FIG. 7.—Here the crack origin is displaced slightly from the point of impact. The origin appears to be a line rather than a point.

If cracks were initiated by an elastic wave (as distinguished from a major distortion of the sample), a definite relation would be expected between the distance between two origins occurring in the same plate, the radii of the cracks, and the velocity of the elastic disturbance. No such relationship, however, could be found to correlate all the photographs. (Figure 8 is an exception.)

Within the resolving power of the method used to find the velocities (average velocity over about $^3/_4$ inch), the velocity was constant at 5040 feet per second (± 1 or 2%) and independent of direction and position. Inasmuch as all cracks studied thus far were initiated by percussion, there is still speculation as to the validity of these results for cracks initiated by slowly applied loads.[2] It can only be said in this connection that

[2] Results obtained since this paper was written seem to indicate that 5000 ft. per second is only a limiting velocity—that any velocity up to 5000 ft. per second could be obtained under the right conditions.

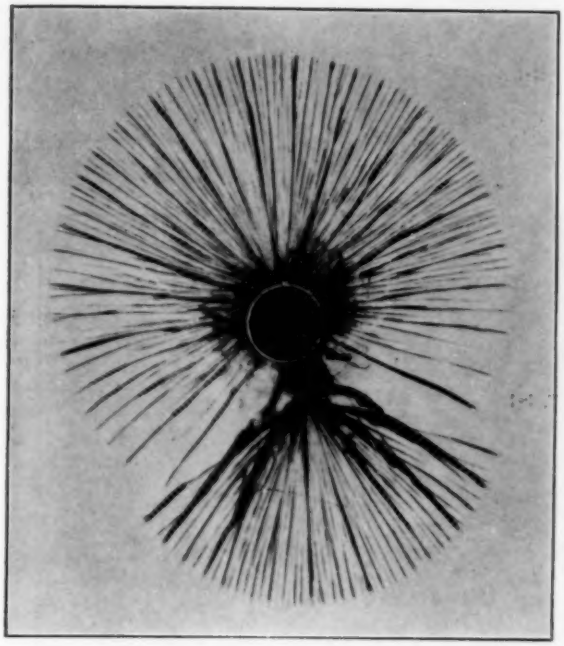

FIG. 8.

FIG. 8.—This unusual case (and one other not shown) has caused considerable discussion. It appears as if cracks had started at two different origins at different times, with the disturbance traveling from the first origin to the second with a velocity close to that of sound. It has been suggested, on the other hand, that the initial crack is always a linear phenomenon with each end forked, that usually the forking takes place almost immediately, but that in this case forking was delayed more on one end than on the other, giving rise to two "fans" of different radii. Figure 7, showing a line origin, would also tend to verify this assumption. If moving pictures sufficiently close together in time had been taken, this viewpoint could readily be checked.

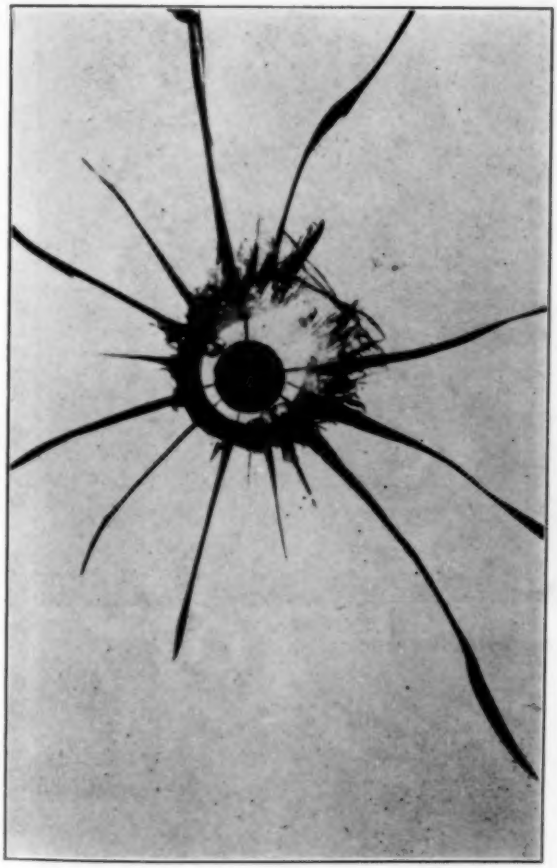

FIG. 9.

FIG. 9.—This photograph is typical of a number of breaks, showing only a few large cracks and a much more steep-sided percussion cone. The shorter cracks show no "blur" at their tips and therefore may be considered "dead" (as explained for Fig. 4). These and all other unusual shots occurred at random, and no definition of the difference in conditions causing them could be learned from this work.

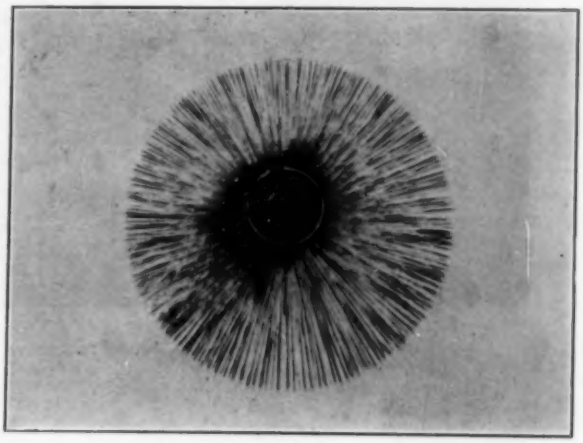

FIG. 10.

FIGS. 10 AND 11.—Two different stages in the development of cracks in tempered glass plates. (Figure 11 is a reduction from a foot-square plate.) As mentioned before, the tempering of the glass does not affect the velocity of propagation of the cracks.

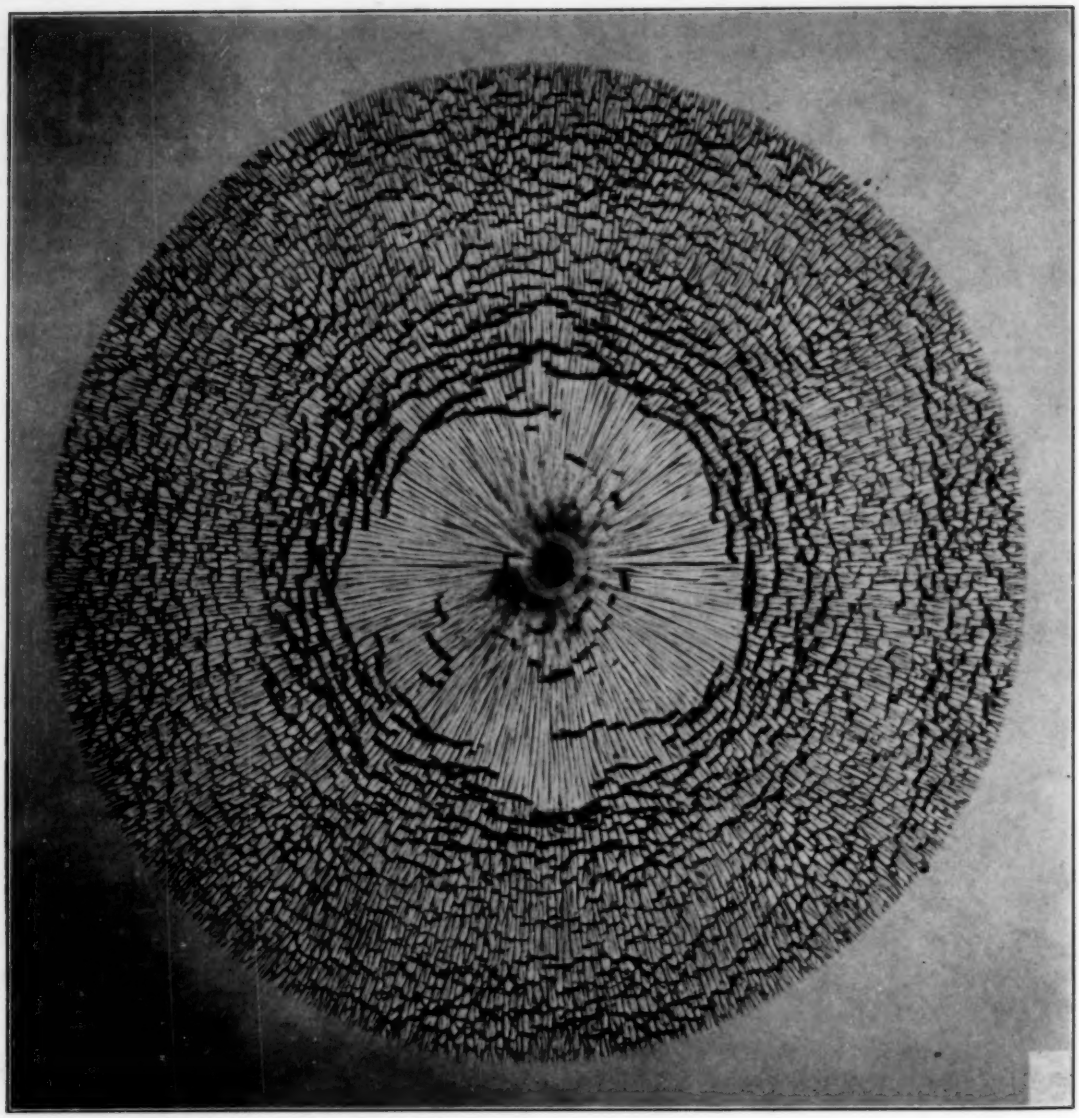

FIG. 11.—Fracture of a tempered glass plate.

FIG. 12.

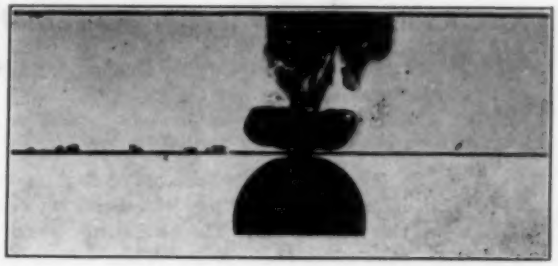

FIG. 15.

FIG. 13.

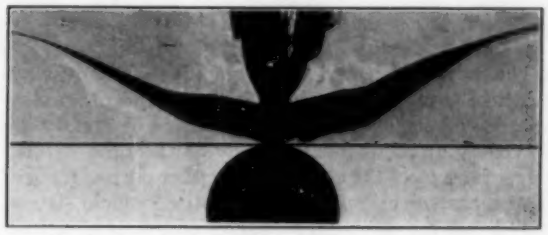

FIG. 16.

FIG. 14.

FIGS. 12 TO 16.—These photographs are side views of square glass rods (photographs taken at right angles to the direction of all the other photographs shown, *i.e.*, cross-section views). Apparently because of the physical dimensions of the samples, no radial cracks occurred, the cracks shown being those forming the percussion cone. It should be stressed again that each photograph is for a different sample of glass. Notice that the cracks start (except for a small button) on the tension side and proceed toward the point of impact (note steel ball), after which they spread out to form a cone. The velocities of these cracks have not been measured.

although Schardin and Struth used a bullet to initiate cracks and therefore applied loads nearly fifty times as fast as those in the work reported here the values of velocity in the two cases agreed almost exactly. In any case, there must be some fundamental reason and explanation for the constancy of the crack velocity. Experiments with glass broken under different conditions as well as experiments using polarized light to determine transient stresses may possibly lead to a more complete understanding of the problem.

Acknowledgment

The establishment of a special Fellowship Fund at the Massachusetts Institute of Technology is making possible a continuation of this study of glass fracture by means of the high-speed photographic methods. Participating in this Fellowship are Corning Glass Works, Hartford-Empire Company, Hazel-Atlas Glass Company, Libbey-Owens-Ford Glass Company, Owens-Illinois Glass Company, and Pittsburgh Plate Glass Company.

The authors also wish to express their appreciation to J. C. Hostetter and H. A. Wadman, Hartford-Empire Company; F. W. Adams, Mellon Institute; W. W. Shaver, Corning Glass Works; G. B. Watkins, Libbey-Owens-Ford Glass Company; and F. W. Preston, for reading this manuscript and offering many helpful suggestions.

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FACTORS INVOLVED IN IMPROVEMENT OF CLAYS THROUGH p_H CONTROL*

By George J. Barker and Emil Truog

Abstract

The p_H-controlled process of clay treatment will produce beneficial results if proper information on the clay is available before treatment. The p_H curve usually will supply this information. Three different types of curves are presented and discussed. Soluble salts affect the process. These effects and manner of control are explained. Actual tests which have been made in plant operations during the past year and the results obtained are described.

I. Introduction

The workability and other qualities of many clays used in the manufacture of brick, tile, and other clayware have been shown by the writers to be greatly improved by an adjustment, usually at the time of pugging, of the p_H of the clays within rather narrow ranges.[1] In the case of clays which are naturally acid, it was stated that the optimum p_H values or points of adjustment fall within the narrow p_H range of 6 to 8.5; with clays which are naturally nonacid, the optimum points of adjustment fall within the p_H range of 7.3 to 10.5. It was also indicated that sodium carbonate, because of its cheapness and effectiveness, is the substance usually recommended for the p_H adjustment or control of clays.

During the past year, the p_H-adjustment process of treating clays has been applied to many clays from various parts of the country. These tests have included trials in the laboratory where conditions could be closely controlled and also in commercial plants in which unexpected disturbing factors are often encountered. In the plants where proper control of the factors involved was obtained, the results have been satisfactory. The present study is devoted chiefly to a discussion of the more important additional data and information obtained in these laboratory and plant tests.

II. Laboratory Investigations

(1) The Optimum p_H

The optimum p_H to which a clay should be adjusted through the addition of sodium carbonate may be determined as follows:

To a series of 20-gram samples of the clay contained in beakers, 50 cubic centimeters of distilled water are added to each, with varying amounts of sodium carbonate which usually range from 0.1 to 1.0% of the weight of the dry clay. After stirring occasionally and after about 10 minutes, the p_H of the clay suspension is determined by the glass electrode. The resulting p_H values are plotted on the vertical axis, the corresponding percentages of sodium carbonate are added on the horizontal axis, and a curve is drawn through the points of intersection. At a certain stage, this curve usually flattens out rapidly and becomes practically horizontal. The p_H range which corresponds to this stage in the curve is the optimum p_H range for the clay under consideration, and this range of course may be attained by adding the corresponding quantity of sodium carbonate.

The question may be raised as to why the optimum p_H for acid clays is usually considerably lower than for the nonacid. In the earlier study,[1] it was indicated that flocculation and deflocculation of clays are largely controlled by p_H and by the nature of the cations which saturate the base-exchange material present in clays. X-ray analysis by a number of workers has shown that this base-exchange material consists of minute crystals which have a platy or layer-like structure. The exchangeable cations are held between the layers which are far enough apart to allow the entrance of water and thus to permit free interchange of various cations as well as water with the exterior medium. When the base-exchange material of a clay is largely saturated with calcium and magnesium, it tends to flocculate or granulate and to produce a nonplastic clay; saturation partially or wholly with sodium, however, greatly facilitates deflocculation and thus the plasticity and workability of the clay. This is possibly due to the great attraction of the sodium ion for water. Thus when considerable sodium is present in the exchange material there is so much attraction between the exchange particles and the surrounding water that the particles hydrate and swell and then disperse and bring about deflocculation.

In the case of the acid clays, the base-exchange material is usually saturated largely with varying proportions of hydrogen, calcium, and magnesium, depending on the degree of acidity, and the p_H value is always below 7. When sodium carbonate is added, hydrogen is first displaced and the p_H rises. When the p_H reaches a point within the range 6.0 to 8.5, depending on the particular clay under consideration, a sufficient amount of sodium has entered the exchange material to bring about the desired deflocculation and thus increased plasticity.

In the case of the nonacid clays, however, the base-exchange material is almost completely saturated with calcium and magnesium, and the p_H value is already 7

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* Presented at the Forty-First Annual Meeting, American Ceramic Society, Chicago, Ill., April 19, 1939 (Structural Clay Products Division). Received April 19, 1939.

The Wisconsin Alumni Research Foundation has given financial support to this investigation.

[1] G. J. Barker and Emil Truog, "Improvement of Stiff-Mud Clays Through p_H Control," *Jour. Amer. Ceram. Soc.*, **21** [9] 324–29 (1938).

or higher. To displace a sufficient amount of these cations with sodium to promote the desired deflocculation, it is necessary to raise the p_H still higher (usually considerably higher than in the case of acid clays) through the addition of sodium carbonate. In the reaction that follows, the displaced calcium and magnesium are precipitated as insoluble and therefore inactive carbonates.

Because of a great variation in the original or natural p_H of clays and in the nature of cation saturation, the p_H (optimum p_H) at which sufficient sodium enters the exchange material to bring about the desired results will vary over a certain range for different clays as well as in the amount of sodium carbonate needed.

(2) Three Types of p_H Curves

As a result of a large number of tests, the curves obtained in plotting percentages of sodium carbonate added against p_H values obtained may be classified usually into three types. These three types, designated *A*, *B*, and *C*, are illustrated in Fig. 1.

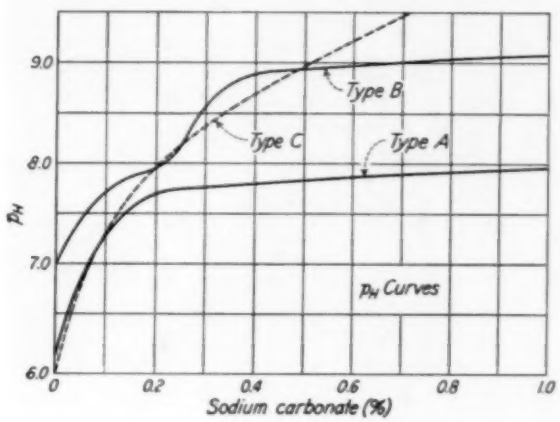

FIG. 1.

The *A* type of curve, one that goes up rapidly and uniformly and flattens rather abruptly, is usually produced by a clay that responds readily and markedly to p_H adjustment. The optimum p_H for the clay represented by curve *A* in Fig. 1 is approximately 7.7, and this is attained by adding approximately 0.2% of sodium carbonate. Clays that produce this type of curve offer no particular difficulty in the application of the p_H-adjustment process, and when a clay of this kind is encountered, there is good assurance that the treatment will produce marked benefits.

When a clay produces the *B* type of curve, *i.e.*, one with a slight preliminary flattening that reverses again before a permanent flattening occurs, it is good evidence that the clay probably contains considerable amounts of soluble salts which must be inactivated before p_H adjustment will give the desired benefits. The soluble salts usually present in clays are calcium, magnesium, ferrous, and ferric sulphates, and if the acidity is very high even free sulphuric acid may be present.

These sulphates usually arise from the weathering, particularly oxidation, of sulphides of iron which are often present in shales and poorly drained subsoils. When shales containing sulphides are mined, placed in piles, and allowed to weather to facilitate subsequent grinding or when clay subsoils containing sulphides are placed in piles and allowed to weather for several years, these sulphides become oxidized and give rise to sulphuric acid and to various sulphate salts. When a clay having a history of one of the types mentioned is treated with sodium carbonate for p_H adjustment, a portion of the sodium carbonate reacts with these sulphates and forms sodium sulphate, which, being soluble and a good electrolyte, promotes flocculation and thus retards the beneficial deflocculation that ordinarily arises from p_H adjustment.

To prevent this action, it is necessary to change the sulphate to an insoluble form. It is well known in the clay industry that this may be accomplished by the addition of barium carbonate or hydroxide, which is a common procedure to prevent scumming caused by the presence of calcium sulphate. Calcium sulphate is undesirable from two standpoints in that it causes scumming and flocculation.

If only moderate amounts of calcium sulphate are present, i.e., ordinarily not more than 500 p.p.m., its flocculating effects are usually insufficient to interfere seriously with the benefits of deflocculation that accrue from p_H adjustment. It is unnecessary to add a barium compound to precipitate the sulphate in this case, even from the scumming standpoint. The sodium carbonate which is added reacts with calcium sulphate and forms insoluble calcium carbonate and soluble sodium sulphate. The latter compound does not cause scumming on the fired ware because, at the usual firing temperature, it melts and then reacts with silicates. If larger amounts of sulphate are present, however, inactivation through the addition of a barium compound is necessary to make the p_H-adjustment process work properly. The addition of the sodium carbonate in this case might prevent scumming in the manner explained, but so much sodium sulphate would be formed that marked flocculation would follow. In applying the p_H-adjustment process, therefore, it is advisable to test the clay first for soluble sulphates so that proper steps may be taken for their inactivation if they are present in considerable amounts.

The *C* type of curve rises gradually and has no stage of abrupt flattening. Several clays that give this type of p_H curve have been received in this laboratory. Nearly all of these clays are yellow or brown and are usually sandy in nature. Laboratory tests indicate that p_H adjustment will make these clays more plastic and lessen the water required. No test runs in commercial plants have yet been made with this type of clay. The present investigations of these clays, however, are being continued, and it is hoped that more information concerning their treatment will be obtained within the near future.

III. Test Runs in Commercial Plants

Of the test runs made in commercial plants, examples

illustrating a wide variety of conditions and special problems are given, rather than examples only in which the p_H-adjustment process works most satisfactorily.

(1) Tests of Shale Clays

A trial run was made in a commercial plant which was manufacturing a high-grade face brick from shale. The shale was hauled from the bank and dumped in a storage shed. To each car was added a small amount of barium carbonate. The clay was moved from the storage shed to a dry pan and, after crushing and screening, to a combination pug mill and brick machine. The reagent feeder was set to discharge sodium carbonate into the dry pan at a rate sufficient to raise the p_H of the clay to 8.0. When raised to this p_H, the clay passed through the die more readily, the clay column was somewhat stronger, and the cut edges of the brick were smoother. After the brick were fired, moisture absorption and crushing-strength tests of the treated and untreated brick were made. The superintendent of the plant selected representative samples for these tests. The results (average of 5 tests) are as follows:

	Moisture absorption (%)				
Brick	24-hr. cold soak	5-hr. boil	*C/B* ratios	Crushing strength (lb./sq. in.)	Increase in strength (%)
Treated	2.93	5.38	0.55	10,660	55
Untreated	5.4	8.36	0.65	6,874	

Moisture absorption in this case was decreased, and strength was greatly increased. As the quality of the brick without treatment is satisfactory, the cost of the treatment is hardly justifiable in this plant on the basis of improved quality. Whether the savings (1) in breakage, (2) in fuel, owing to a shorter firing time, and (3) in power, owing to improved workability, might more than offset the cost of the treatment is open to question. The test shows, however, that clays even of high quality may be improved by the treatment.

At a stiff-mud brick plant using a weathered shale, the results obtained in the plant test from p_H adjustment were not entirely satisfactory. It was found, however, that in the weathering of the shale considerable sulphate had formed which seriously retarded the deflocculating effects of the treatment. The one noticeable benefit was that the clay passed through the brick machine more easily. The machine was equipped with an ammeter which indicated approximately a 20% decrease in power consumption when treated clay was being used. The transverse and crushing strength of the treated and untreated dry brick were approximately the same. The brick which had not been treated averaged 12,330 lb. per sq. in. crushing strength; the treated brick averaged only 9690 lb. per sq. in. The cold water, 24-hour moisture-absorption test gave the same result in each case, namely 5.4%. The 5-hour boil test result was 7.52% for untreated brick and 8.18% for treated brick. This is a case in which the p_H-adjustment treatment alone does not improve the product.

This clay produces the *B* type of p_H curve (Fig. 1), and before an improvement can be made in the product by the p_H-adjustment process, it probably will be necessary first to inactivate the soluble sulphates present. The quality of the ware being produced is fairly satisfactory, and the cost of a complete treatment might not be justified by the possible improvement.

(2) Test at a Drain-Tile Plant

At a drain-tile plant using a calcareous surface clay, longitudinal cracks appeared in the ware during and after the firing period. Visual examination of the dried ware which had been formed in a deairing machine disclosed no cracks. When a freshly formed green tile, however, was cut longitudinally and laid out flat, numerous parallel cracks opened (Fig. 2). These cracks are planes of weakness caused by the failure of the clay particles to knit together properly.

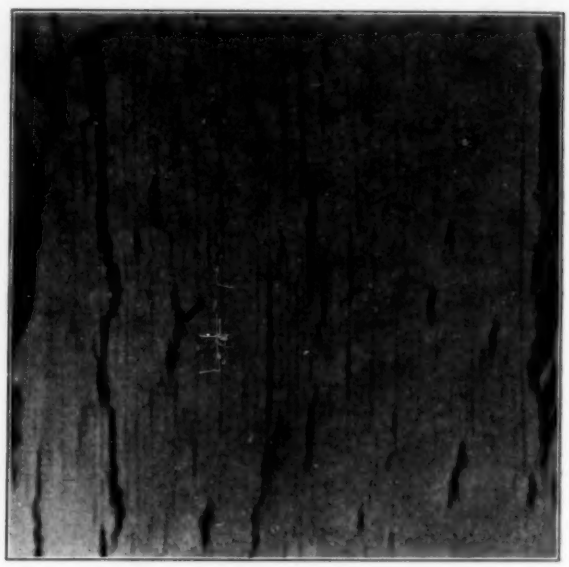

FIG. 2.—Untreated clay.

This clay produces the *A* type of p_H curve (Fig. 1), which indicates that a simple treatment alone should produce marked benefits. In a trial run, sodium carbonate was added in a quantity sufficient to produce a p_H of 9.2. As soon as the treated clay passed from the machine, a difference in physical appearance was noted. No tempering water was used at this plant, and the treated clay came from the die in a softer condition, which increased the extrusion rate so that at times the men handling the tile could hardly keep pace with the machine. In order to keep the clay stiff enough to form good tile, crushed dried clay was added to the feed. Because the supply of this dry material was limited, there was some difficulty in holding the clay column to the proper stiffness. The addition of the sodium carbonate, however, reacted as expected in that it caused the clay to bond or stick together, which decreased the cracks.

Figure 3 shows a sheet cut from a tile made with treated clay. This sheet had been given several work-

ings back and forth by hand to open up any cracks which might be in the clay. Close examination disclosed no longitudinal cracks, although there were some breaks around the dry nodules of clay which did not wet and become bonded to the clay body. The test demonstrated that the treatment will produce a tougher and more plastic body with this type of clay and thus a better drain tile.

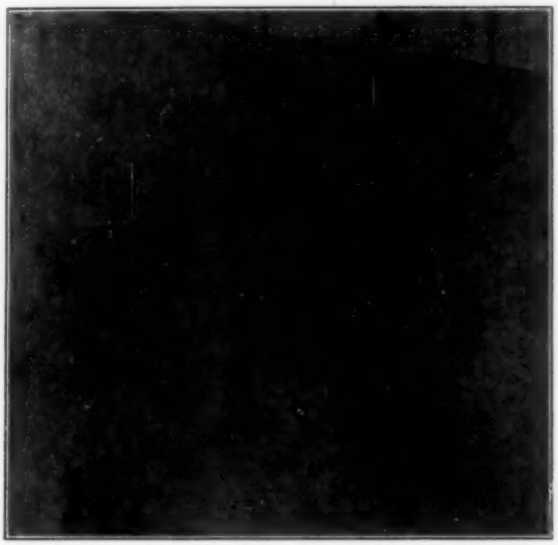

FIG. 3.—Treated clay.

(3) Test in Hudson River Valley District

Another clay which involved difficulties when the p_H-adjustment treatment was applied in the plant was that found in the lower Hudson River Valley. This calcareous clay theoretically should respond markedly to treatment. The peculiar conditions at the plants in this district, however, present a special problem. The clay bank is composed of alternate layers of clay and fine silt, the latter usually being saturated with water. The large amount of free water makes this clay so soft that it can not be used as taken from the bank for the manufacture of a stiff-mud product. Soft-mud common brick for this reason are the main product. It is a customary practice in the district to add lime in the form of calcium hydrate to dry the clay. What really happens is that the lime causes the clay to become more flocculated and granular, which helps to keep the wet brick in shape. Operating conditions may require the addition of this lime, but from another viewpoint, it is undesirable because it produces a brick of less strength and of greater moisture absorption.

This clay produces the *A* type of p_H curve, which indicates that marked improvement in the quality of the product should be obtained from p_H adjustment. When some of the clay was dried and subjected to laboratory tests, marked benefits were derived from p_H adjustment. When the treatment was applied in a commercial plant, however, difficulties were encountered. Upon the addition of the sodium carbonate, the clay immediately softened, and when the full treatment was applied, the clay mass became so soft that the brick lost their shape on the pallet. The clay became more workable, however, and the wet brick could be deformed to a greater degree without breaking. By limiting the amount of sodium carbonate added to a partial treatment, it was possible to make a brick which did not deform on the pallets. After these brick had been fired, the treated brick were sounder and had fewer defects. The physical tests applied later clearly showed that improvements had been effected as follows:

	Moisture absorption (%)				
Brick	24-hr. cold soak	5-hr. boil	*C/B* ratio	Crushing strength (lb./sq. in.)	Increase in strength (%)
Treated	10.1	13.9	0.72	3130	18.5
Untreated	20.1	24.4	0.83	2640	

The decrease in moisture absorption is so material that the p_H adjustment treatment should be considered from this standpoint alone. The problem, however, of drying the clay within allowable costs so that the brick will not deform will have to be worked out, and this is a challenge to the ability of the ceramic engineer.

(4) Test in Chicago District

The Chicago district is the second largest producer of clay products in the United States. Stiff-mud, end-cut brick are made so rapidly that foreign visitors are amazed at the speed of manufacture. The clays used here are chiefly calcareous with a p_H above 7. The clays mined in this district vary from plant to plant, and it is not uncommon to have from three to five different types of clay in the various layers or levels of the same clay bank. These clays have long intrigued the ceramist; and the manufacturers, because of keen competition, have long sought to improve their products.

Difficulties were encountered in the application of the p_H-adjustment treatment to these clays, and only after laboratory experimentation for two years was it deemed advisable to make a test run in a commercial plant. When everything was ready, a trial run was made at the Brisch Brick Company plant at Stickney, Ill. This company manufactures brick at the rate of 300,000 per eight-hour day, and the first trial run had to be planned so as not to interrupt this rate of operation. The reagent feeder was set to deliver the desired amount of sodium carbonate, and when the plant was in full operation, word was given to start the test. One hundred thousand brick were made without interrupting operations.

The results obtained were as expected. The first effect was a softening of the clay column, and because no mixing water could be used, some dried and ground clay was added to obtain a clay column of the desired stiffness from the brick machine. The speed of extrusion of the column was increased about 5%. The plant operators could feel the difference immediately in the body of the clay because it had a better "slip." The men handling the brick from the belt could tell the difference because there was less breaking of the edges in

their hands. Because the clay body was now more dense and compact, a slightly higher temperature (20°F) in the drier was required to dry the brick in the same amount of time. The brick passed through the drier without cracking, and they were considerably stronger when dry than the untreated brick. This additional strength is important because mechanical loaders are used to set the brick in scove kilns.

The treated brick were fired in the same manner as the other brick, and the effect of treatment was easily noticeable when the kilns were opened after firing. The color was materially different from that of the regular Chicago brick and some pleasing color effects have been achieved in houses built with these brick. The fired treated brick had a better body structure which reduced the quantity of broken brick in a kiln. This savings in breakage will nearly pay for the cost of the reagent. The fired brick that were treated were stronger and had a lower moisture absorption.

IV. Summary

When varying amounts of sodium carbonate are added to samples of a clay, and the p_H values thus produced are plotted on the vertical axis against the amount of sodium carbonate added, a curve is obtained which is peculiar to one of three types. Some clays give an *A* type of curve, which at a certain stage flattens rapidly and becomes nearly horizontal; other clays, i.e., those containing considerable amounts of soluble salts, give a *B* type of curve which has a preliminary flattening that reverses and then flattens permanently; other types of clays, especially those of a sandy nature, give a *C* type of curve, which exhibits no definite stage of rapid flattening. The stage at which rapid flattening takes place in the *A* type represents the p_H and amount of sodium carbonate which give the most desirable results in the p_H-adjustment process of treating stiff-mud clays. Clays which give the *B*-type curve contain considerable amounts of soluble salts that have to be inactivated before the treatment produces the desired benefits. Clays which give the *C* type of curve do not usually respond as markedly to the treatment.

The results are given of trial runs, involving a variety of clays, of the application of the p_H-adjustment process in a number of commercial plants. When the problems peculiar to the clays and type of plant operation were handled properly, an advantage from the treatment was obtained in all cases in one or more of the following characteristics, viz., strength, breakage, water absorption, color, and power consumption.

In some cases, especially where a satisfactory product is produced without treatment, the advantage obtained by treatment may not justify the cost, but in the majority of cases, the gain far exceeded the cost.

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Compiled by the

AMERICAN CERAMIC SOCIETY

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September, 1939

18—9

Abrasives

Airplane engine efficiency owes much to modern precision grinding jobs. Anon. *Can. Machinery*, **50** [3] 36–37 (1939).—Modern grinding machines have speeded up the production of cylinders from two cylinders per hour in 1927, which always needed to be honed to obtain mirror finish, to four cylinders per hour which can be directly installed in the motor without honing, due to superior finish in grinding. The grinding of nitrided steel cylinders presented a problem which was quickly overcome. The problem of grinding irregular contours in some components, especially in the grinding of engine cylinders which have to be ground with special allowances for cylinder expansion due to a heated engine, was also solved. D.A.B.

Centerless grinding tips. Gottfred B. Fyrberg. *Can. Machinery*, **50** [5] 29–30 (1939).—A careful study of each job determines the abrasive to be used, together with the bond, grain, and grade, and the structure of the wheel. Longer wheel life, a greater rate of production, a larger number of pieces per dressing, and a lower rejection result. Aluminum oxide abrasive is best for steel and high tensile strength materials, and silicon carbide abrasive is best for low tensile strength materials. Bonds and regulation or feed wheels are discussed. D.A.B.

Close grinding limits essential on controllable pitch air screws. Anon. *Can. Machinery*, **50** [6] 124, 126 (1939). —The close check placed on the majority of grinding operations which are necessary on controllable pitch air screws is emphasized. D.A.B.

Cylinder-honing methods show progress in efficiency. Anon. *Can. Machinery*, **50** [5] 21–23, 51–52 (1939).—The lapping method, employing various types of split pistons and emery powder or powdered glass, was unsatisfactory because there was more wear on lap than on the material being ground. The internal or planetary grinding process and its disadvantages are mentioned. Abrasive blocks on holders with springs to regulate the tension against the cylinder was the next method developed, followed by segmental blocks. The introduction of the hand brake type head speeded up cylinder honing, but because of manual skill and proficiency of operator required it was replaced in time by the three finger automatic tool having automatic expansion and contraction. Stone and shell assemblies are described in detail and the series of honing tools is illustrated. D.A.B.

Diamond grinding wheels for fine grinding and lapping of metal carbides. Anon. *Werkstatt & Betrieb*, **71** [19–20] 260–61 (1938).—The use of diamond grinding wheels for metal carbides is historically reviewed. Their bedding materials, including ferrous and nonferrous metals (solid and powdered-sintered), metal carbides, and organic material, are described. Details for the construction of grinding machines and their applications and standard speeds are given. J.M.N.

Formation and dissociation of silicon carbide. Otto Ruff. *Trans. Electrochem. Soc.*, **68**, 87–109 (1935).—In the formation of amorphous or microcrystalline silicon carbide (SiC) by interacting quartz and coke, carbon monoxide is evolved at a pressure of more than one atmosphere at temperatures above 1635°C. Experimental equipment and procedure are described. The reaction is inaugurated by the softening and melting of the quartz while in contact with the solid coke. Silicon vapor is produced which, through a secondary reaction, is consumed as SiC. The course of the reaction is described in detail. The pressure of silicon vapor above solid SiC and graphite is immeasurably small after equilibrium has been attained at 1635°C. The boiling points of the reaction constituents at 1 mm., 10 mm., and 760 mm. are tabulated. Roland Brunner's research (*Ceram. Abs.*, **14** [1] 15 (1935)) on SiC formation from SiO_2 and C is critically reviewed. The supposition that siloxicon is a necessary intermediate product in the formation of SiC is unwarranted and contrary to experimental observations. The dissociation of SiC at various temperatures can be most accurately determined by measuring the equilibrium pressures of the gas phase above solid SiC and graphite, employing the spring balance method which is described in detail. The components of the gas phase were determined, and from this analysis the partial pressures of silicon in contact with solid SiC and graphite are derived. The vapor pressure of liquid silicon was determined and its heat of vaporization calculated. On the basis of the experimentally determined heat of formation of solid SiC and the heat of vaporization of liquid silicon, the partial pressures for silicon

vapor in contact with solid SiC and graphite are calculated; these calculated values are identical with those found empirically. The temperature of a commercial SiC furnace is selected not so much on the basis of minimum temperature required for the silicon carbide reaction to take place as on a basis of a temperature characteristic for any particular furnace design which will bring about the carbide reaction at the best possible speed and efficiency. The reasons for the maintenance of a maximum temperature in the commercial silicon carbide furnace are discussed. In the recrystallization of silicon carbide, it is suggested that an intermediate carbon-oxygen compound is formed which is richer in C than CO. In the commercial carbide furnace the reaction sequence is more important than reaction equilibria. The presence of silicon in the gas phase of commercial furnaces is due to its formation as an intermediate product before combining with carbon to form the carbide. Localized condensation of larger masses of silicon is due to irregular operation of the furnace. Illustrated. F.G.H.

Grinding with diamond metal. ANON. *Werkstatt & Betrieb*, **72** [3–4] 42 (1939).—Diamond grains are imbedded (without change in their structure) in a metal alloy with a tensile strength of 70 to 80 kg./mm.^{2}. The grains are very closely packed. The diamond metal is made in layers $^1/_4$ to $^1/_2$ mm. thick; it is used for grinding and lapping metal carbide tools and for grinding threads. J.M.N.

Impact abrasion hardness of molded boron carbide and of some cemented tungsten and tantalum carbides. LOWELL H. MILLIGAN AND RAYMOND R. RIDGWAY. *Trans. Electrochem. Soc.*, **68**, 131–37 (1935).—Abrasive blast tests on different grades of some cemented tungsten and tantalum carbide alloy materials gave relative abrasion hardness values. The hardest product of this kind studied had a hole depth of 20×10^{-4} in. (0.051 mm.) after the test, corresponding to an impact abrasion number of 1500. Corresponding tests on molded boron carbide products gave an average of 13×10^{-4} in. (0.033 mm.) for the best products. This corresponds to an impact abrasion number of 2700. For impact abrasion resistance, molded boron carbide is approximately fifteen times as suitable as crystals of boron carbide. See *Jour. Amer. Ceram. Soc.*, **19** [7] 187–91 (1936). F.G.H.

Industrial uses of furans. FREDUS N. PETERS, JR. *Ind. Eng. Chem.*, **31** [2] 178–80 (1939).—P. discusses the use of furfural as a solvent in the manufacture of resin-bonded abrasive wheels. F.G.H.

Polishing stainless steel welds. C. H. S. TUPHOLME. *Sheet Metal Ind.*, **12** [129] 77–78 (1938).—A great deal has been written on the correct technique of the oxyacetylene welding of stainless steel, but very little information is available on how to finish the welds. Practical notes are presented on grinding, polishing, and buffing. A.P.S.

Quest for hard materials. FRANK J. TONE. *Ind. Eng. Chem.*, **30** [2] 232–42 (1938).—A brief history of abrasive materials is given. The production of silicon carbide and aluminum oxide by fusion in the electric furnace forms the foundation for the abrasive industry as we know it today. Since these compounds are comparatively cheap and are efficient for most purposes, there seems to be little probability of their being replaced by harder materials except for special applications. T. discusses the properties of boron carbide, silicon boride, silicon carbide, and fused combinations of these materials from the standpoints of hardness and abrasive qualities. The factors which affect the cutting properties of various types of abrasives are considered. The refractory properties of silicon carbide, aluminum oxide, and fusions of the latter with chrome ore are also briefly discussed. Excellent photomicrographs of most of the materials described are presented. F.G.H.

Thread-grinding operations for airplane components make rapid strides. ANON. *Can. Machinery*, **50** [3] 42, 94 (1939).—Wheel-profiling, dressing, and thread-grinding machines are described. D.A.B.

PATENTS

Abrading element. HOWARD G. BARTLING (Minnesota Mining & Mfg. Co.). Can. 381,733, May 30, 1939 (Jan. 31, 1936). G.M.H.

Abrasive-coated fabric. R. C. BENNER AND R. L. MELTON (Carborundum Co.). Can. 381,337, May 9, 1939 (July 13, 1935; in U. S. July 18, 1934). G.M.H.

Abrasive paper. JAMES A. YATES (Brown Co.). Can. 381,388, May 16, 1939 (Nov. 6, 1936; in U. S. March 2, 1936). G.M.H.

Abrasive sheet. HOWARD G. BARTLING (Minnesota Mining & Mfg. Co.). Can. 381,897, June 6, 1939 (Jan. 31, 1936). DURWARD OGDEN GUTH (Minnesota Mining & Mfg. Co.). Can. 381,434, May 16, 1939 (Jan. 31, 1936). G.M.H.

Abrasive wheel. MERTON B. LANE (Norton Co.). Can. 381,301, May 9, 1939 (Oct. 21, 1936; in U. S. Nov. 8, 1935). G.M.H.

Apparatus for dressing the grinding wheels used for gearing. M. G. E. PHILIPPE (Société dite: La Bougie B. G.). U. S. 2,166,020, July 11, 1939 (April 30, 1937).

Apparatus for grinding two surfaces of any object whose surfaces lie in parallel planes. RICHARD ROTTER (Deutsche Edelstahlwerke A.-G.). Ger. 673,304, March 2, 1939 (Feb. 3, 1937); XII/67*a*. 13.—Two surfaces of any object having these surfaces in parallel planes are ground by means of a device which is inserted into and out of the space between two grinding disks. The coupling surfaces of the inserting device are provided with countersunk bearings (ball type) to facilitate proper rotation; these bearings rest against installed hardened plates, to allow an easy movement of the workpiece in a direction vertical to the grinding surfaces, while it is fixed in an immovable position in the direction parallel to the grinding surface. Ger. 674,027, March 16, 1939 (Feb. 11, 1937); XII/67*a*. 13. Addition to 673,304.—All surfaces securing the object to be ground in the coupling device are provided with bearings, rollers, or casters to facilitate rotation. D.A.B.

Apparatus for grinding uneven surfaces curved on all sides, *e.g.*, parts of wire press forms used in briquette presses, etc. HEYMER & PILZ A.-G. Ger. 673,260, March 2, 1939 (Feb. 23, 1935); XII/67*a*. 31.03. Addition to 656,739.—Apparatus is described. D.A.B.

Apparatus for lapping toothed elements. H. L. BARTER (Packard Motor Car Co.). U. S. 2,165,329, July 11, 1939 (April 15, 1935).

Apparatus for regrinding double edged plane blades for razors. ALFRED KARGER AND GEORG PETROV. Ger. 673,306, March 2, 1939 (March 23, 1937); XII/67*c*. 5.—Mechanical details for grinding apparatus are given. D.A.B.

Apparatus and method for grinding and polishing bore holes. E. T. MEAKIN. U. S. 2,165,566, July 11, 1939 (July 13, 1935).

Attachment for cutter grinders. R. K. LE BLOND MACHINE TOOL CO. U. S. 2,164,212, June 27, 1939 (April 21, 1938).

Automatic grinding device. ARTHUR LEMAY. U. S. 2,164,155, June 27, 1939 (Dec. 22, 1938).

Automatic honing mechanism and control means therefor. C. W. FLOSS. U. S. 2,164,811, July 4, 1939 (Feb. 15, 1938).

Automatic multiple lawn mower grinding machine. S. W. MCGEE. U. S. 2,164,830, July 4, 1939 (Aug. 25, 1938).

Bonded ceramic article. L. H. MILLIGAN AND R. H. LOMBARD (Norton Co.). Can. 381,577, May 23, 1939 (Oct. 21, 1936; in U. S. Nov. 7, 1935). G.M.H.

Boron carbide article making apparatus. R. R. RIDGWAY AND B. L. BAILEY (Norton Co.). Can. 381,942, June 6, 1939 (Oct. 4, 1934); see "Method—, "*Ceram. Abs.*,**15** [3] 96 (1936). G.M.H.

Crankshaft lapping machine. H. S. INDGE (Norton Co.). U. S. 2,166,009, July 11, 1939 (July 20, 1938). W. H. WOOD (Norton Co.). U. S. 2,166,084, July 11, 1939 (Oct. 3, 1938). U. S. 2,166,086, July 11, 1939 (Feb. 18, 1939).

Gem-grinding machine. E. C. SMITH. U. S. 2,163,987, June 27, 1939 (Aug. 31, 1937).

Grinding machine. CHARLES HERFURTH (Cincinnati Grinders, Inc.). U. S. 2,164,875, July 4, 1939 (Jan. 31, 1938). M. I. MATHEWSON AND A. L. KRAUSE (Brown and

Sharpe Mfg. Co.). U. S. 2,165,898, July 11, 1939 (Nov. 14, 1935).

Grinding and polishing machine. R. W. FULLER (Production Machine Co.). U. S. 2,165,097, July 4, 1939 (Dec. 31, 1936).

Grinding wheel. A. P. BEEBE (Peninsular Grinding Wheel Co.). U. S. 2,164,560, July 4, 1939 (Feb. 7, 1938).—A segmental grinding wheel.

Hollow or cylindrical body for holding a helical spring during grinding of its end surfaces. HARTEX G.M.B.H. MASCHINEN- UND WERKZEUGFABRIK. Ger. 673,419, March 2, 1939 (Nov. 15, 1935); XII/67*a*. 31.10.—A hollow or cylindrical body for holding a helical spring during the grinding of its ends is provided with a spiral grooving on either the outer surface of the body or in the interior which serves as a medium for holding the tension spring during the grinding and which corresponds to the windings and cross section of the spring. D.A.B.

Hone. H. L. BLOOD (Heald Machine Co.). U. S. 2,164,867, July 4, 1939 (March 11, 1936).

Honing machine. A. M. JOHNSON (Barnes Drill Co.). U. S. 2,163,604, June 27, 1939 (April 21, 1937).

Lapping machine. W. H. WOOD (Norton Co.). U. S. 2,166,085, July 11, 1939 (Nov. 3, 1938).

Machine for grinding cutting blades. H. N. NORMAN. Brit. 507,371, June 28, 1939 (May 12, 1938).

Making abrasive articles by means of precoated grain. A. G. SCUTT (Carborundum Co.). U. S. 2,164,476, July 4, 1939 (March 15, 1935).—In a method of making an abrasive article comprising a resin and granules with surfaces of low adhesive characteristics with respect to the resin, the steps consist in mixing the particles and a resin of the phenol formaldehyde condensation product type, setting the mixture under heat and at pressures sufficiently exceeding 5000 lb./sq. in. to force the resin into any uneven portions of the surfaces of the particles, disintegrating the resulting mass and separating granules with adhering resin, mixing the last-mentioned granules with a resin bond in sufficient amount to produce a substantially nonporous article on the application of high pressure, and molding the last-mentioned mix under heat and pressure.

Making a buffing wheel or wheel section and the product thereof. E. W. HALL. U. S. 2,165,752, July 11, 1939 (Sept. 16, 1937).

Manufacture of abrasive alumina. BLAKESLEE BARNES (Chemical Construction Corp.). U. S. 2,163,532, June 20, 1939 (Sept. 22, 1937).—A method of preparing abrasive alumina comprises impregnating bauxite with a liquid carbonaceous material, calcining to form a finely divided reducing agent within the pores of the bauxite, mixing the calcined material with a flux, and fusing the mixture.

Means for shaping and truing the operating surfaces of grinding wheels used for form grinding. COVENTRY GAUGE & TOOL CO., LTD., AND S. J. HARLEY. Brit. 508,006, July 5, 1939 (Nov. 23, 1937).

Method and apparatus for honing workpieces. H. L. BLOOD (Heald Machine Co.). U. S. 2,164,868, July 4, 1939 (July 24, 1936).

Method and machine for grinding gears. ERNEST WILDHABER (Gleason Works). U. S. 2,164,978, July 4, 1939 (Jan. 6, 1937).

Method and means for forming or dressing grinding wheels used for form grinding. COVENTRY GAUGE & TOOL CO., LTD., S. J. HARLEY, AND J. E. WAINWRIGHT. Brit. 507,281, June 28, 1939 (Oct. 1, 1938).

Optical profile grinding machine. R. M. WOHLFARTH (A.-G. vorm. Seidel & Naumann). U. S. 2,164,169, June 27, 1939 (July 21, 1938).

Polishing machine. J. P. COX (General Motors Corp.). U. S. 2,165,616, July 11, 1939 (July 1, 1937).

Production of boron carbide. I. G. FARBENINDUSTRIE A.-G. Ger. 673,534, March 9, 1939 (Jan. 30, 1936); IV*b*/12*i*. 37.—In a method for producing boron carbide from hydrated boric acid and carbon in an electric furnace, the mixture is subjected to the action of an electric arc. D.A.B.

Production of polished surfaces. R. EASTEN AND N. SHAW. Brit. 506,771, June 14, 1939 (Dec. 10, 1937).

Screw-thread cutting or grinding machine. E. R. ELFORD. Brit. 506,436, June 14, 1939 (Jan. 15, 1938).

Silicon-carbide compositions. CARBORUNDUM CO. Fr. 835,080, Dec. 12, 1938; *Chem. Abs.*, **33**, 4388 (1939).—The compositions consist of SiC impregnated with Si, the carbide being substantially in continuous phase but of reticulated structure. Articles are molded from a mixture of finely divided C and a carbonizable substance, *e.g.*, flour, sugar, or casein. The shaped articles are placed in contact with Si and heated to a temperature, *e.g.*, above 1800°, to cause the Si to penetrate into the pores formed in the articles and to form SiC. The proportion of Si is in excess of that required to fill the pores. The articles obtained are suitable for use as electric resistances.

Track rail grinding machine. WALTER HOBSON AND H. H. WOODROW. U. S. 2,163,908, June 27, 1939 (Oct. 3, 1936; July 18, 1938).

Waterproof abrasive article. FRANK J. CRUPI (Minnesota Mining & Mfg. Co.). Can. 381,294, May 9, 1939 (Jan. 31, 1936). G.M.H.

Waterproof abrasive fabric. FRANK JOSEPH CRUPI (Minnesota Mining & Mfg. Co.). Can. 381,432, May 16, 1939 (Jan. 31, 1936). G.M.H.

Waterproof and oilproof abrader. WILLIAM LUXMORE (Minnesota Mining & Mfg. Co.). Can. 381,433, May 16, 1939 (Jan. 31, 1936). G.M.H.

Water-resistant abrasive product and method of making. C. R. WALKER (Abrasive Products, Inc.). U. S. 2,165,186, July 4, 1939 (Nov. 7, 1936).

Wheel-grinding machine. W. T. BITLER, M. S. EVANS, AND R. P. MCBRIDE (American Car and Foundry Co.). U. S. 2,164,491, July 4, 1939 (May 17, 1938).

Art and Archeology

Athenian cup in the form of a cow's hoof. G. M. A. RICHTER. *Bull. Metropolitan Mus. Art*, **33** [10] 225–26 (1938).—An unusual Athenian cup in the form of a cloven hoof surmounted by a red-figured scene has been acquired by the Museum. The style is Athenian, about 470 to 460 B.C. The lower part was molded and the upper part was thrown on the wheel. The only other Attic cup in this form is in the National Museum at Naples. A.A.A.

Birds of salt-glazed stoneware. *Connoisseur*, **103** [454] 315 (1939).—Full page color illustration showing stoneware birds enameled in bright colors (turquoise, yellow, and rose); they are from the J. Henry Griffith collection. M.E.P.

Chien Lung porcelain bowls. H. COMSTOCK. *Connoisseur*, **103** [452] 219–20 (1939).—These *Famille Rose* pieces are decorated with the Three Fruits (pomegranate, citron, and peach) symbolizing the Three Abundances of years, sons, and happiness. They are marked with a six-character seal mark in underglaze blue. Illustrated. M.E.P.

Conversion of raw lead glazes into fritted glazes. H. HARKORT. *Keram. Rundschau*, **46** [48] 559–61; [49] 571–74; [50] 582–84; [51] 600–601 (1938).—The economical and the technical viewpoints are discussed. The melting points of lead silicates vary according to previous treatment. It is possible to obtain the conversion by (1) a reduction of glaze firing temperature, the composition remaining the same; (2) an increase of acidity, the temperature being constant; (3) a change in the nature of the bases, acidity and temperature being constant. Lead frits are raw materials allowing a multiplicity of compositions and suppressing lead poisoning during manufacture. F.E.V.

Craftsmanship at San Francisco. EMILY JOSEPH. *Magazine of Art*, **32** [7] 402–409 (1939).—In a review of the contents of the Decorative Arts Division of the Fine Arts Building at the Fair, J. mentions some of the fine

glass and ceramics included in the exhibit. Illustrations include Russell Barnett Aitken's "Congo" punch bowl, Maurice Marinot's bottle of blue glass encasing red opaque glass, Jeanette Dyer Spencer's stained glass window, Orrefors' vase of engraved glass, and H. V. Poor's two pottery pieces. M.E.P.

Craquelé glazes. ANON. *Keram. Rundschau*, **46** [2] 16 (1938).—The reduction of quartz, tin, and kaolin in ordinary glazes gives *craquelé*. Tensions in outer and inner glazes must be in equilibrium. Examples of nonfritted and fritted glazes are given. During firing, protection against sulfur must be ensured. F.E.V.

Discoveries at Mersin. ANON. *Antiquity*, **13** [50] 238–42 (1939).—John Garstang discovered at Mersin, Cilicia, the remains of a fortified city about 20 ft. below the imperial Hittite fortress discovered last year. The culture is related to that of Uruk and El Ubaid and to the polychrome phase of the Tel Halaf culture of Mesopotamia (3600 B.C.). The mud brick are large, regular in shape, and well laid. Missiles for use in a large sling were made of fired clay, but large pebbles were also used. Cooking pots, storage jars, and other vessels decorated with painted designs were in good condition. Even the kitchen pots, though plain, were freely burnished and finished with a shiny black or deep-brown surface. The handles have distinctive shapes. A number of trichrome jars with rosette decoration of broad bands of red and salmon pink with deep black lines was found at the 16th level. The buildings represent the oldest architecture yet known and show a civilization in Cilicia which was well advanced when Egypt, Mesopotamia, and Crete were still in their infancy. The 15th-level pottery has cultural affinities with that of El Ubaid, with decorative bands on a cream surface. A new type of chalice and bowl forms decorated with flowing white lines on a burnished black or brown surface have been discovered. At 30 ft. below the 16th level are two main features of neolithic culture in which black and brown pottery (some of it decorated in simple ways) is associated with obsidian tools; it is attributed to not later than 5000 B.C. Still older levels are yet to be excavated. A.B.S.

Dummy. ANON. *Science News Letter*, **35** [13] 211 (1939).—A tumbler made by the people of Susa, in the region now Iran, has been lent to the Buffalo Museum of Science by the Louvre in Paris. This ware was made about 4000 B.C. and is so fragile and fired at so low a temperature that it could not be used for holding any material. The pieces were placed in graves. The ware is admired by archeologists, who say Susa's potters have seldom been surpassed in workmanship. P.G.H.

Dutch porcelain. D. KIGHLEY BAXANDALL. *Connoisseur*, **103** [453] 258–62 (1939).—The illustrations in this article are from the collection of W. S. de Winton at the National Museum of Wales. Although the Dutch were not among the earlier manufacturers of porcelain, Dutch porcelain is all hard paste; the glaze is white, translucent, and even, and the overglaze colors are well united with it. Most of the Dutch porcelain is marked. Only five factories are known to have produced porcelain in Holland. The first was founded at Weesp in 1764 by Count Gronsveldt-Diepenbrock. The importation of German workers caused a Meissen influence in style and decoration. This factory lasted only 7 years. It was then moved to Loosdrecht, where the ware shows some Sèvres and a little Japanese influence. The mark at this time was M.O.L. accompanied by a star. About 1784 the works was removed to Oude Amstel which was the longest-lived factory, lasting 16 years. The mark then was usually the word "Amstel" in script; this was also the mark of the short-lived Nieuwe Amstel factory. Oude Amstel was forced to close about 1800 when English creamware flooded the country. The factory at The Hague, founded by a Viennese, Anton Leichner, in 1775, had only one kiln and employed about 50 men. The Hague mark was a stork with a fish in its bill. The Hague pieces are elaborately painted in polychrome and grisaille, and the shapes are much more rounded than Amstel pieces. This factory failed about 1786. The last Dutch porcelain factory was founded by George Dommer at Nieuwe Amstel in the early 19th century; the ware made there won a medal at the 1st Industrial Exposition at Utrecht in 1808. This factory closed in 1810. M.E.P.

Egyptian, Roman, and Near Eastern gifts. G. M. A. RICHTER. *Bull. Metropolitan Mus. Art*, **33** [11, Sect. 1] 240–42 (1938).—Two amphorae among the best extant have recently been given to the Museum by John D. Rockefeller, Jr., to augment the collections of blue-, green-, and brown-glazed pottery dating from the Hellenistic and Roman imperial periods. They are wheel thrown, of a yellowish sandy clay, have molded reliefs separately applied, are low fired, and are glazed outside and in with a copper alkaline glaze. It is difficult to date the pieces precisely, but it is known that the ware began not later than the 1st century B.C. and continued at least until the 3rd century A.D. A.A.A.

Fine Italian majolica at Sotheby's. ANON. *Pottery & Glass Record*, **21** [6] 142–44 (1939).—Several fine specimens of Italian majolica ware of the late 15th century are described. They are from the collection of A. Pringsheim of Munich, recently sold at Sotheby's Galleries in London. Some of the prices are mentioned. A.B.S.

Glass batches 3000 years old. W. GANZENMÜLLER. *Glashütte*, **69** [1] 6–10 (1939).—Glass was made in Egypt in 4000 or 3500 B.C., but no written record of how it was made has yet been found to show that it was anything but an accidental accomplishment. Up till now the oldest piece of glass, dating from 2700 to 2600 B.C., was found in Mesopotamia: it is blue and irregularly formed and was used for glaze. The oldest glass recipe yet discovered was deciphered from clay tablets dating over 3000 years ago (C. J. Gadd and R. C. Thompson, A Middle-Babylonian Chemical Text. Iraq III, 1936, pp. 87–96). Ancient Assyrian glassmaking and glass recipes are discussed. Glassmaking was intimately associated with religion and was kept in great secrecy by the priests. See "History—," *Ceram. Abs.*, **18** [8] 201 (1939). M.V.C.

Greek vases. Recent accessions. CHRISTINE ALEXANDER. *Bull. Metropolitan Mus. Art*, **34** [4] 98–100 (1939).—A proto-Corinthian flask, a Corinthian vase, and a proto-Attic fragment were acquired. The first, an aryballos or ointment flask, is from the first quarter of the 7th century B.C. The vase, a small hydria, about 575 to 550 B.C., is decorated with the figure-painting story of Herakles in single combat with a centaur. The fragment of a proto-Attic vase has a lion's head. The grandeur of the vase may be guessed from the large scale of the treatment of the head. Vases of this style were made about 625 B.C. A.A.A.

Heraldic stained glass at Gray's Inn: V. F. SYDNEY EDEN. *Connoisseur*, **103** [452] 198–202 (1939).—Continuing the story of the ancient heraldic glass in the windows of the inn, the author takes up the description of the glass in the window next to the bay, which is interesting for the painting and quality of the glass. Illustrated. For Part III see *Ceram. Abs.*, **18** [8] 201 (1939). M.E.P.

Iranian Expedition (1937). W. HAUSER, J. M. UPTON, AND C. K. WILKINSON. *Bull. Metropolitan Mus. Art*, **33** [11, Sect. 2] 3–23 (1938).—An account of the third season of excavation of the Museum's Iranian Expedition at Nishapur in eastern Iran is given. The new ceramic finds from Nishapur greatly enrich the Museum's collections of early Islamic pottery and help to confirm the importance of Nishapur as an artistic center of eastern Iran. Among the types discovered, all dating from the 8th to the 10th century and described in this article, are some which are common to the whole of eastern Iran and western Turkestan as well as those peculiar to Nishapur kilns. During earlier excavations, the influence of China and Mesopotamia was noticed. This time, actual importations were discovered, including early celadon and stoneware from the T'ang dynasty (A.D. 618 to 906) and fragments of polychrome luster ware of the Samarra type. See *Ceram. Abs.*, **17** [9] 297 (1938). A.A.A.

Longton Hall tureen. HELEN COMSTOCK. *Connoisseur*, **100** [433] 212 (1937).—C. describes this interesting example of English porcelain from the short-lived (1752 to

1758) Longton Hall factory of William Littler. The decoration shows the background of Littler's blue, a cobalt blue which was widely used at Longton Hall in imitation of the scale blue of Worcester or of the *gros bleu* of Vincennes. White enamel washed in the form of scroll work was unique with this factory. The guilding was unfired gold leaf. Illustrated. M.E.P.

Near Eastern ceramics and textiles. HANNAH E. MCALLISTER. *Bull. Metropolitan Mus. Art*, **33** [11, Sect. 1] 242–44 (1938).—Three 12th-century jars from Rakka recently given by John D. Rockefeller, Jr., are important additions to the Museum's collections of Near Eastern ceramics. Two of the jars are similar, having the inverted pear shape with relief decoration under a rich turquoise blue glaze. On one, the design is not only in relief but is painted in black, and there are black dots on the background. Both are of a pinkish white earthenware and show characteristic Rakka iridescence. The third jar is taller with three curved handles with decoration painted in black under a slightly greenish transparent glaze. A.A.A.

Pottery and porcelain. Recent accessions. JOSEPH DOWNS. *Bull. Metropolitan Mus. Art*, **33** [12] 271–72 (1938).—Recent purchases from the Rogers Fund include (1) a Chinese Lowestoft porcelain toddy jug (1792 to 1796) in a rare pattern not represented in the Museum's collections, the arms of the United States being displayed on each side of the barrel-shaped body; (2) a pair of pottery figures in the form of a stag and a doe from the Bennington, Vt., factory; Daniel Greatbach, famous English potter working at Bennington from 1852 until 1858, is believed to have made the models for these figures; (3) a teapot and sugar bowl of glazed earthenware with representations of the ships "Cadmus" and "Clermont," probably made at Bristol for the American market about 1825. A.A.A.

Present status of colorimetry. M. G. MELLON. *Ind. Eng. Chem., Anal. Ed.*, **11** [2] 80–85 (1939).—In reviewing the present status of colorimetry, M. directs attention especially to the importance of colorimetric methods of measurement (as revealed in current periodicals and two comprehensive treatises); the variety of applications already made, together with the general limitations of such measurements; and a classification of the kinds of methods available for making colorimetric measurements, including suggestions for a consistent usage of terms. Illustrated. F.G.H.

Recent gifts to the American wing. MARSHALL DAVIDSON. *Bull. Metropolitan Mus. Art*, **34** [4] 95–96 (1939).—A recent gift to the Museum from R. Thornton Wilson includes a distinctive example of American glass, a purple covered bowl similar to some others found in western Ohio. There are a helmet-shaped pitcher and a small cup of Chinese hard-paste porcelain bearing the insignia of the Order of the Cincinnati and two punch bowls of the so-called Chinese Lowestoft which are of unusual interest. See "Porcelain—, *Ceram. Abs.*, **15** [7] 198 (1936). A.A.A.

Russian national types in porcelain. HELEN COMSTOCK. *Connoisseur*, **103** [452] 217 (1939).—Three figurines made at the Russian Imperial Porcelain Factory in the reign of Catherine II are illustrated. They represent regional and racial types of the Russian empire and are modeled by Rachette from original drawings by Ioann Georgi in the 1780's. M.E.P.

Three Lowestoft mugs. *Connoisseur*, **100** [433] 214 (1937).—Full-page illustration in color showing three mugs decorated in colors, one with a view of a ropewalk and the other two with personal names and the dates, 1774 and 1787. These are from the Wallace Elliot collection. M.E.P.

Tournai soft paste. HELEN COMSTOCK. *Connoisseur*, **103** [450] 99–100 (1939).—The porcelain factory at Tournai was run by François-Joseph Peterinck whose title arms (crossed swords with crosslets between) he also used as a mark for his porcelain. Distinguished sculptered pieces and decorated services were turned out. A plate from the Symons Galleries having a *bleu de roi* and gold border and a scenic design that seems to be an engraving casually dropped on the center of the plate is illustrated. The factory was founded by François Carmontel in 1750, but Peterinck purchased it a few months later. He brought decorators from Rouen, notably Claude Borne, and by 1752 employed 43 workers. See "Porcelain—," *Ceram. Abs.*, **16** [11] 343 (1937). M.E.P.

Twelfth century Byzantine enamel. JAMES J. RORIMER. *Bull. Metropolitan Mus. Art*, **33** [11, Sect. 1] 244–46 (1938).—A Byzantine enamel plaque has been given to the Museum by Mary Ann Blumenthal. It is from the famous Botkine collection and represents the Virgin Mary with Saint Simeon and the Christ Child. Like most other Byzantine enamels it is of the cloisonné variety. A.A.A.

Two Meissen porcelain vases. C. L. A. *Bull. Metropolitan Mus. Art*, **34** [3] 74–75 (1939).—Two large porcelain vases made at Meissen have been turned over to the Museum through the generosity of the late Alfred Duane Pell. They belong to the period of about 1725 to 1730 when, under the patronage of Augustus the Strong, the factory was rising to first rank. Inspired by oriental models they are adaptations rather than copies. A.A.A.

Two models of coaches in spun glass. *Connoisseur*, **103** [452] 221 (1939).—Full page color illustration showing spun glass models, made about 1837, representing a Royal Mail coach and a nobleman's equipage. They were probably made at Bristol and are $11^1/_2$ in. long and 4 in. high. M.E.P.

Vase by Meidias. G. M. A. RICHTER. *Bull. Metropolitan Mus. Art*, **33** [12] 262–64 (1938).—A large two-handled jar decorated with figures reserved in red clay against the black-glaze background has been recently acquired by the Museum. It gives a glimpse of major Greek painting and was made by Meidias, the greatest ceramic painter of the late 5th century. A.A.A.

Water bottle of Staffordshire salt-glazed stoneware. *Connoisseur*, **103** [453] 262 (1939).—Full page color illustration of a bottle painted with enamel colors in the Chinese manner. It dates from about 1760 to 1770 and is from the J. Henry Griffith collection. M.E.P.

Josiah Wedgwood and his portraits of 18th century men of science. J. C. PHILIP. *Proc. Roy. Inst. Gt. Brit.*, **30** (Part 3) [142] 497–517 (1938).—Josiah Wedgwood's phenomenal success as a potter was due to his application of science to industry. He linked himself with several scientific bodies. Through the medium of his medallions, plaques, and busts he has bequeathed to the 20th century an incomparable portrait gallery of his scientific contemporaries. In designing and modeling many of these he engaged many artists. From the artistic viewpoint the best of these was the master sculptor Flaxman. P. describes the work of these artists and their subjects. Illustrated. See *Ceram. Abs.*, **18** [7] 172 (1939). G.M.H.

BOOK

Catalogue of Contents of the Museum of Freemasons' Hall in the Possession of the United Grand Lodge of England. Vol. 1, Ceramics, Glass, Furniture, Jewels, Medals, Badges, Aprons, and Other Regalia. Compiled by ALGERNON CRAIG. 36 illustrations, 41 pp. Price £2 2s net. Reviewed in *Pottery & Glass Record*, **21** [6] 149–51 (1939).—Specimens of Chinese porcelain, mostly Chien Lung period (late 18th century), especially those having the beautiful self-colored red enamel color of *Famille Rose* decoration, are included. The *Famille Rose* punch bowl (1753), enameled with European Masonic emblems after a color print by William Tringham, is described. Two specimens were presented by King George V in June, 1934. Intrinsically pleasing Germanic porcelain figures with the Order of Mopses are variously represented. The Museum is fortunate in possessing one made at Meissen about 1741, designed by Joh. Joachim Kaendler, representing the Elector of Saxony with apron, collar, and jewel; a mops is at his feet. There are two beautifully reproduced color plates, both modern Dresden; one, by Kaendler, is of the Countess Kozel with a mops in her left arm and another at her feet. The other, a two-

figure group, depicts Augustus II dividing the world with Adolphus Frederick, King of Sweden (1710–71); a mops is at the Elector's feet. A comprehensive series of Sunderland transfer-printed jugs, bowls, etc., some with luster decoration and some of associate Staffordshire types, is presented. Leeds, Liverpool, and Wedgwood ware, tankards, jugs, and teapots, some transfer printed with fanciful designs, verse, and masonic emblems, have an important place in the designs represented. Rockingham, Worcester, and Staffordshire examples are of outstanding interest. Other pieces are miscellaneous items, mauls, water bottles (one in Glasgow stoneware), Staffordshire and Brislington delftware, etc., including a primitive earthenware oil lamp from the period of King Solomon's Temple (960 B.C.). Another group includes china ashtrays, clay pipes, etc. The glass, which is from a variety of sources, is for the most part not outstanding in regard to age or beauty with the exception of an early Waterford goblet (1730). Eight page plates of the glass pieces include many examples of old Masonic Lodge glass. A.B.S.

PATENTS

Apparatus for producing designs on glass. MAX TISCHER. Ger. 673,413, March 2, 1939 (June 8, 1935); VI/32*b*. 7.—An apparatus for producing designs on glass by chipping off small particles from the glass surface is provided with a chipping tool of hard metal with a point tipped with a diamond, etc.; the apparatus possesses a drive which sets the tool in a vibrating or striking motion. D.A.B.

Decorating glass objects with ceramic colors. HERBERT VOGT (Gebr. Putzler Glashüttenwerke G.m.b.H.). Ger. 674,058, March 16, 1939 (Dec. 22, 1937); VI/32*b*. 8.—A colorless fluxing agent or one varying in color from that of the color base is applied over or under a base consisting of ceramic colors in places on the glass object; the fluxing agent is applied in such an amount that the thinning of the color base which results upon firing is negligible. D.A.B.

Designs for:

Bottle. ALLAN'S BEVERAGES, LTD. Can. 12,380, May 17, 1939. CARLING-KUNTZ BREWERIES, LTD. Can. 12,383, May 17, 1939. G.M.H.

Bottle. A. C. BURGUND (Carr-Lowrey Glass Co.). U. S. 115,388, June 27, 1939 (April 20, 1939). P. G. LLOYD (Carr-Lowrey Glass Co.). U. S. 115,415, June 27, 1939 (April 24, 1939).

Combined glass candlestick and vase holder. E. W. HEISEY (A. H. Heisey & Co.). U. S. 115,400, June 27, 1939 (March 20, 1939).

Glass bottle. JOHN HARVEY KEENS. Can. 12,396, May 25, 1939. G.M.H.

Goblet. E. M. BOTTOME (Fostoria Glass Co.). U. S. 115,642 and 115,643, July 11, 1939 (April 17, 1939).

Hollow glass building block. J. H. SUTTER (Owens-Illinois Glass Co.). U. S. 115,432, June 27, 1939 (May 5, 1939).

Jar. J. L. HENDRICKSON (Hazel-Atlas Glass Co.). U. S. 115,652, July 11, 1939 (Nov. 25, 1938). GEORGE SMITH, JR. (Olean Glass Co.). U. S. 115,529, July 4, 1939 (Nov. 8, 1938).

Jug. J. L. HENDRICKSON (Hazel-Atlas Glass Co.). U. S. 115,516, July 4, 1939 (Jan. 13, 1939).

Lavatory. G. W. KOHLMEYER (W. A. Case & Son Mfg. Co.). U. S. 115,623, July 11, 1939 (May 10, 1939).

Plate. E. M. BOTTOME (Fostoria Glass Co.). U. S. 115,665, and 115,666, July 11, 1939 (April 17, 1939). M. G. YUTZEY (Fostoria Glass Co.). U. S. 115,637, July 11, 1939 (April 6, 1939).

Porcelain and china. GRIMWADES, LTD. Can. 12,338, April 21, 1939. G.M.H.

Porcelain insulator. L. A. STOHL. U. S. 115,530, July 4, 1939 (Jan. 21, 1939).

Sugar bowl. M. G. YUTZEY (Fostoria Glass Co.). U. S 115,638, July 11, 1939 (April 6, 1939).

Tea and coffee pot. AUGUST UNGER (Firma A. Riedeler und August Unger). Ger. 673,031, Feb. 23, 1939 (Oct. 9, 1937); X/34*f*. 11.06.—A tea or coffee pot has a sugar bowl and creamer acting as the lid of the pot. The sugar bowl is built into the top of the pot, and the creamer is provided with a rim that enables it to act not only as a lid to the pot but also as a cover for the sugar bowl. D.A.B.

Tumbler. E. W. FUERST (Libbey Glass Co.). U. S. 115,492 and 115,493, July 4, 1939 (Nov. 21, 1938). M. O. HANSEN (Libbey Glass Co.). U. S. 115,496, July 4, 1939 (Nov. 21, 1938).

Water jug. W. T. STOPA (Edison General Electric Appliance Co.). U. S. 115,531, July 4, 1939 (Dec. 14, 1938).

Fluxing agent for decoloring glass. SIOTO G.M.B.H. Ger. 674,450, March 23, 1939 (Nov. 11, 1935); VI/32*b*. 2.—A fluxing agent for decoloring glass consists of barium borosilicate, together with a content of alumina and alkali, and contains an addition of decoloring agent melted into the mixture in an amount necessary to complete the decoloration of the entire glass batch to which the fluxing agent is added. D.A.B.

Cements

Binding properties of compounds of the calcium aluminate and silica type. V. F. ZHURAVLEV. *Tsement*, **5** [7] 43–45 (1938).—It has been found microscopically that there are several double compounds in the system CaO–Mn_2O_3. The compound that is presumably $3CaO \cdot Mn_2O_3$ has well-defined binding properties. Other CaO and Mn_2O_3 compounds do not have these properties. Preliminary data on the mechanical strength of $3CaO \cdot Mn_2O_3$ show a continuous increase in strength of moist stored samples, a regularity of volume change, and no cracks or curvatures. See "Periodicity—," *Ceram. Abs.*, **18** [1] 8 (1939). P.B. & E.S.

Effect of heating on the strength of cements. I. E. GURVICH. *Tsement*, **5** [12] 28–31 (1938).—Slag Portland cement increases in strength when heated to 250° for 1-, 3-, and 7-day samples and shows no increase for 28-day and 5-month samples. At 500° the strength falls somewhat except for 5-month samples which do not change. At 800° to 900° the strength falls abruptly to 15 to 30% of the initial value. For 28-day and 5-month samples the changes of strength are about the same as those for 3-month samples of high-grade Portland cement, except at 1300° where high-grade Portland cement has a strength much higher than the initial value and slag cement has a 50 to 60% lower strength. After air storage for 10 months, the heated samples increased in strength. The increase of strength at 100° to 300° is attributed to the evolution of water adsorbed by the cement gel and to the accelerated crystallization of $Ca(OH)_2$. At 500° the character of the dehydration curve changes on account of the start of the dehydration of $Ca(OH)_2$ which ends at 800°. Further solidification takes place as a result of clinkering of Portland cement. P.B. & E.S.

Fibrolite based on unfired dolomite. L. L. LIPSHITZ. *Stroitel. Materialy*, **1938**, No. 8–9, pp. 56–62.—Unfired dolomite mixed with a $MgSO_4$ solution reacts as follows: $CaCO_3 + MgCO_3 + MgSO_4 \cdot 2H_2O = 2MgCO_3 + CaSO_4 \cdot 2H_2O$. The crystallization of gypsum is one of the essential factors of hardening of unfired dolomite, with the recrystallization of $MgSO_4$ also playing a part. Fibrolite tile thus prepared under plant conditions proved quite satisfactory. The investigations made and the production process worked out are described. P.B. & E.S.

Litharge-glycerin cement. T. ZIENER. *Oberflächentech.*, **16** [12] 121–23 (1939).—A cement for joining metals and glass, but also for joining glass with glass, porcelain, and earthenware, is made of dry litharge and enough pure water-free glycerin to give, in mixing, a stiff pasty mass

which hardens in 10 to 30 min. This cement is weatherproof (even in the tropics). It resists acids, alkalis, essential oils, chlorine and alcohol vapors, benzine, and temperatures up to 260°C, is vacuum proof, and becomes stone-hard. The joints should first be made rough because adhesion is not good on smooth glass surfaces. The longer the time of hardening, the more glycerin is used. Exact procedures for different conditions and applications are described. M.H.

Pozzuolanas. *Dept. Sci. Ind. Research Rept., Bldg. Research Board*, **1938**, pp. 8–11.—There are no natural pozzuolanas in Great Britain, but a long research just completed at the Building Research Station shows that first-rate pozzuolanas can be made by heating certain clays at controlled temperatures. The materials are now employed commercially as additions to Portland cement. A.B.S.

Reactions between silica and calcium oxide in aqueous solutions and their relation to pozzuolanic action. ALFRED E. BEITLICH. *Jour. Amer. Chem. Soc.*, **60** [8] 1832–36 (1938).—The modern conception of pozzuolanas defines them as materials which, though not cementitious in themselves, contain constituents which will combine with calcium oxide at ordinary temperatures in the presence of water to form stable insoluble compounds possessing cementitious properties. Most natural or artificial pozzuolanic materials are generally composed of silica, alumina, iron oxide, and calcium oxide. Magnesia, potassium, and sodium oxides and possibly other elements in very small quantities may be present. In contrast to Portland cement, no definite chemical composition can be ascribed to pozzuolanas; the type of oxides present and their percentages vary within wide limits. They are materials of very complex mineralogical aspects, and complete petrographic researches are still lacking. Only one thing is common to all pozzuolanas, and that is their ability to harden under water or in air in the presence of moisture when mixed with calcium oxide or a material which liberates calcium oxide. From previous work, it has been established that the presence of water, silica, and calcium oxide is important for the development of pozzuolanic action. This study, therefore, is confined to the reactions between silica and calcium oxide in aqueous solutions, thus eliminating many complicating factors. On the basis of the results secured by means of the conductivity method and under the conditions of the experiment, the reactions between calcium oxide and silica proceed in the following manner. With dilute solutions the silica adsorbs calcium oxide in accordance with the Freundlich adsorption isotherm. Above an initial ratio of CaO/SiO_2 of 0.30 and up to 0.60, chemical combination takes place, and a reaction product is formed in which the ratio of CaO/SiO_2 is 1 to 2. This product is stable in a solution containing 1.5 m.e. of calcium oxide per liter. On increasing the calcium oxide concentration above an initial ratio of 0.60, adsorption again takes place which proceeds until the initial ratio of CaO/SiO_2 is 0.90 and the ratio of combined CaO/SiO_2 is 4 to 5. The reaction product with the ratio of $4CaO$ to $5SiO_2$ is stable up to an equilibrium concentration of 10 m.e. of calcium oxide per liter. With higher concentrations of calcium oxide and initial ratios from 1.3 to 3.75, a third range of adsorption reactions takes place. As the point of saturation of the calcium oxide solution at equilibrium is reached, the ratio of CaO/SiO_2 in the reaction product approaches 2:1, indicating the probable existence of a hydrated $2CaO \cdot SiO_2$ in saturated calcium oxide solution. Illustrated. F.G.H.

BOOK

Portland Cement. RICHARD K. MEADE. Chemical Publishing Co., New York, 1939. 3d ed. 707 pages, 206 illustrations, 75 tables. Price $10.00.—This treatise comprehensively covers the history of cements, their production and use, classification, raw materials, manufacturing methods and equipment, composition and mineral constitution, methods for analyzing and testing, and the entire subject as it was known a decade or two ago. M. is an excellent and trustworthy writer. No one else has so completely presented what was known about cement technology. Meade, in all honesty, does not venture to present the later day scientific researches and findings on the relation of cement constitution and preparation to such properties as strength, stability, and refractoriness of cement products. R. C. PURDY

PATENTS

Device for preliminary heating of a sintered cement charge. ARNO ANDREAS. Ger. 666,318, Sept. 22, 1938 (Sept. 19, 1933); V/80*c*. 14.10. Addition to 568,620. D.A.B.

Manufacture of magnesium oxychloride binding mediums and compositions. P. J. ROUZARD. Brit. 507,982, July 5, 1939 (Sept. 13, 1937).

Producing magnesium oxychloride. FRITZ WIENERT (Magnesium Development Corp.). U. S. 2,163,819, June 27, 1939 (Dec. 18, 1936).

Rotary kiln divided into longitudinal cells for drying charges such as cement. KLÖCKNER-HUMBOLDT-DEUTZ A.-G. Ger. 671,931, Feb. 2, 1939 (June 23, 1936); V/80*c*. 14.10.—A rotary kiln is divided into longitudinal cell units for drying charges such as crudely ground cement by means of heated gases. The charge passes through the drum in one direction, while the gas streams through each cell, first in the same direction as the moving charge and then in the opposite direction. D.A.B.

Sintering cement, etc. FRIED. KRUPP GRUSONWERK A.-G. Ger. 671,825, Jan. 26, 1939 (Dec. 31, 1935); V/80*c*. 13. Addition to 668,460, Nov. 10, 1938.—Cement, etc., is calcined by employing heat in the shaft furnace and adding clinker to the raw charge according to Ger. 668,460. The shaft furnace is charged in the center with raw material and clinker which are in a uniform state of division and at the rim with pure or almost pure charge. D.A.B.

Enamel

Anodic pickling of iron and steel. R. MÜLLER AND L. HARANT. *Trans. Electrochem. Soc.*, **69**, 145–53 (1936).—The pickling of iron and steel on a large scale is usually done in solutions of HCl or H_2SO_4 to which some organic inhibitor is added to prevent excessive localized action of the acid and at the same time prevent or minimize embrittlement of the steel due to the diffusion of atomic hydrogen into the surface of the metal. In electrolytic pickling, when the work to be cleaned is made anode, most metals dissolve, but there is no hydrogen developed at the metal surface as in cathodic pickling. In anodic pickling, the rate of pickling can be controlled within wide limits through current regulation. There is no danger of H_2 embrittlement and the pickling solution need not be an acid; an acidified salt solution will work satisfactorily. In ferrous metals which readily become passive if treated anodically, the loss of metal is not significant. An electrolytically pickled metal will be more resistant to rusting than a metal acid pickled without current. Anodic pickling of iron and steel in 10% H_2SO_4 was compared with that in acidified $FeSO_4$ solutions. Results indicate distinct advantages for the $FeSO_4$ solutions; these are largely due to a possible depolarizing effect of the ferrous ions at the anode. Although high current densities will readily remove scale through the copious evolution of oxygen and cause little loss of metallic iron, low current densities of less than 1 amp./dm.^{2} are more economical in spite of larger metallic iron losses. A 0.4 *N* $FeSO_4$ + 0.3% H_2SO_4 solution is recommended. It pickles more cheaply than ordinary acid solutions without current. Illustrated. F.G.H.

Art enameling. H. N. BOSE. *Indian Ceramics*, **1** [2] 55–60 (1938).—B. discusses the production and application of art enameling and copper enameling together with batch

recipes. By the proper selection of the flux and by the combination of several coloring oxides, all colors can be reproduced in the enamel. B. describes the flux and oxides to be used for blue, green, violet, purple, yellow, orange, red, and black enamels. See *Ceram. Abs.*, **18** [7] 173 (1939). A.P.S.

Bullard-Dunn electrochemical metal descaling process. COLIN G. FINK AND T. H. WILBER. *Trans. Electrochem. Soc.*, **66**, 381–92 (1934); see *Ceram. Abs.*, **17** [2] 56 (1938). F.G.H.

Coating power of enamel slips. RICHARD ALDINGER. *Glashütte*, **69** [5] 71–73 (1939).—Brief instructions are given on the methods for determining the coating power, spreading time, and weight by volume of slips. Although the difficulties which arise because of changing qualities of enamel slips can be minimized by careful supervision of the grinding and fusing operations, the most important factor is the water content of the ground material; a varying water content of wet enamels is the main cause for variations in the coating power of the enamel slip. M.V.C.

Coatings and fluxes in the welding of steel. Review of literature to Jan. 1, 1938. W. SPRAGEN AND G. E. CLAUSSEN. *Welding Jour.* [N. Y.], **18**, Supp. 153–65 (May, 1939). W.H.B.

Copperheads. H. HADWIGER. *Emailwaren-Ind.*, **16** [9–10] 62–64 (1939).—The appearance of copperheads is due to a local concentration of oxides or salts of iron. When the ground coat is fired, the quantity of iron oxide absorbed lowers the fusing point which, in turn, causes a precipitation of crystals of the oxide and a piercing of the glaze. A microscopical examination of the crater formed generally shows hematite crystals. H. studied the cause of this local concentration of oxide. In certain cases the surface structure of the sheet metal explains the accumulation of oxide or residues from picking, such as iron salts, lodged in the pores of the metal. A concentration of soluble salts such as borax causes the glaze to be affected. The fusing point also may be lowered in spots, without the appearance of the abnormal concentration of iron salts. M.V.C.

De-enameling. RICHARD ALDINGER. *Glashütte*, **69** [13] 245–48 (1939).—A. describes the following de-enameling processes: (1) mechanical methods, including crushing with rollers, knocking the enamel off with a hammer, and sandblasting; and (2) chemical methods, including (*a*) treatment with acids (hydrofluoric acid, hydrofluoric acid and sulfuric acid, fluosilicic acid, sulfuric acid, chromic acid, and HCl; (*b*) treatment with alkalis (fused alkali and solutions of caustic soda in water). M.V.C.

Drying enamel coats. VIELHABER. *Emailwaren-Ind.*, **16** [17–18] 111–12 (1939).—The difficulties of drying enameled ware are explained, and the advantages of specially designed apparatus are discussed. M.V.C.

Drying and firing of ground enamel coats. A. DIETZEL AND K. MEURES. *Emailwaren-Ind.*, **16** [9–10] 57–61 (1939).—The origin of dark gray streaks and marks in fired enamel which was applied wet was studied. The cause lay in the uneven drying of the enamel coat. The places which dried rapidly absorbed by capillarity the water-soluble substances from the areas that dried slowly. During fusing, therefore, the reactions in these different places were different and eventually appeared as streaks. The importance of this observation for the drying of unfused grounds is pointed out. The stages of firing enamels with normal or reduced content in soluble substances such as soda and borax are explained, and results of drying in practice are given. M.V.C.

Effect of fineness of grinding and thickness of the enamel coat on opacity. VIELHABER. *Emailwaren-Ind.*, **16** [1–2] 1–2 (1939).—The three factors which affect the opacity of enamels are the thickness of the coat, fineness of grinding of the enamel, and the addition of opacifiers. The use of each of these factors is limited. The enamel coat should be as thin as possible because adherence decreases with increasing thickness; the enamel should be ground as fine as permissible, and the lowest possible amount of opacifier should be used. This ideal can be attained only by tests for every given enamel. M.V.C.

Effect of furnace gases on physical properties of cast-iron enamels. G. H. SPENCER-STRONG. *Jour. Amer. Ceram. Soc.*, **22** [8] 255–60 (1939).

Effects of some electrolytes on consistency of dipping enamels. R. J. WHITESELL. *Jour. Amer. Ceram. Soc.*, **22** [8] 265–70 (1939).

Enameling school at Golden Gate Exposition. ANON. *Enamelist*, **16** [8] 22–23 (1939); reprinted in *Bull. Amer. Ceram. Soc.*, **18** [7] 271 (1939).

Granulation and drying of fused enamels. R. ALDINGER. *Glashütte*, **69** [17] 306–309 (1939).—Quenching the enamel melt in water and drying the granules requires careful supervision, as negligence or carelessness may cause losses and difficulties in subsequent stages of production. In order to obtain granules of uniform structure, constant stirring is necessary while the enamel is being drawn off. This is done mechanically in large-scale operations. Big lumps of enamel are hard to grind and prolong milling; granules with varying water content also cause trouble in milling. In both cases the properties of the enamel slip are changed and difficulties in applying the enamel result. The granules must, therefore, be dried before grinding. In small and medium-sized plants a simple drying chamber heated with waste gas from the furnace suffices, while in large-scale production a sieve centrifuge or drum drier is used. Loss of granules can be prevented with proper precautions, and the hot water resulting from the granulation of enamels should be utilized for pickling or other purposes. M.V.C.

Grates and firing equipment. RICHARD ALDINGER. *Glashütte*, **69** [10] 174–91 (1939).—In the manufacture of enameled ware, the construction and condition of the firing equipment and charging apparatus, racks, etc., has an important bearing on the quality of the ware. Progress in the development of heat-resisting alloys, especially chrome, nickel steel, and lighter weight metal apparatus, permits a greater charge and, therefore, a higher furnace output. Examples from practice are given. M.V.C.

Importance of control of operations in enamel plants. HADWIGER. *Glashütte*, **69** [10] 191–94 (1939).—Every factor in the production of enamels, such as degreasing, firing, pickling, neutralizing, testing the raw materials, fusing processes, grinding, slip consistency, enamel coat, firing conditions, etc., must be closely supervised. M.V.C.

Influence of the surface of the cast iron on its enameling. F. KELLER. *Glashütte*, **69** [9] 153–57 (1939).—The question of cast iron as a function of the impurities it contains is treated. These impurities affect the condition of the surface to be enameled. An increase in the amount of graphite or pearlite in the cast iron has a bad effect on the adherence of enamel. A pearlite which decomposes easily while the enamel is fired is less desirable than a stable pearlite. A high oxide content in the enamel adds a risk to enameling. Due to the fact that an increasing silicon content lowers the solubility of oxygen in the iron, a high silica content with a low carbon content is recommended. A high Mn content is desirable because it favors deoxidation of the cast iron and retards graphitization. A high phosphorus content makes the cast more compact and combats the unfavorable influence of gas contained in the cast iron. Suitable refiring of the cast before enameling is very useful; it brings about the decomposition of carbides and aids the combustion and elimination of graphite. M.V.C.

Latest technical development in enameling. H. J. KARMAUS. *Emailwaren-Ind.*, **16** [13–14] 83–88; [15–16] 99–104 (1939).—New and inexpensive substitutes for enamel raw materials, which do not have to be imported into Germany, are discussed: (1) Opak-Sioglur gives a white opacification and replaces a part of the opacifying agent in the melt; the borax content can be reduced 25%, and opacifiers such as sodium metantimonate can be lowered 10 to 15%. (2) Boryn has the composition 73 SiO_2, 0.78 B_2O_3, 15.30 Na_2O, 1.02 K_2O, 6.85 CaO, 1.95 Al_2O_3, and 0.72% Fe_2O_3. (3) Boryat, another borax sub-

stitute, contains 30.30 SiO_2, 44.50 B_2O_3, 24.51 Na_2O, and 0.35% Al_2O_3 + Fe_2O_3. (4) Proquidol has a zinc-fluorine basis. Gas opacification has been improved and can now be used in most industrial enamels and in enamels with low borax content; with an addition of only 4% gas opacifying agent and a weight of the coat of 8 g./sq. cm., a whiteness of 82% can be obtained. Lead-zirconium silicates, zinc-zirconium silicates, and basic "cersulfates" of the formulas $4CeO_2 \cdot 1SO_3$ to $4CeO_2 \cdot 3SO_3$ are discussed. Two new enameling processes in which several enamel layers are fired simultaneously are mentioned. When the ground and coat enamel layers have similar or approaching firing temperatures, they can be fired together, but the first coat is dried before the second is applied. Two other processes deal with a white edge for enamel instead of the usual blue or black edge; the enamels are opacified with solid opacifiers or by gas-forming agents. Clay is ground to the usual fineness with petroleum, benzene, toluene, or alcohol, and no drying is necessary before firing. These enamels can be made without clay. Another method for enameling black metal (iron or iron alloys) consists in plating the black surface with a layer of light metal which is then anodically oxidized and finally enameled. Enamels with higher melting point can be used here. American and British patents are described for fastening enameled objects to cement surfaces. Innovations in equipment for enamel plants include the following: (1) an American portable mixer with a little motor which turns a long rod to which two propellers are attached; (2) spraying pistols and a special spraying chamber or box in which excess enamel is retrieved and the latest American devices for recovering the enamel by introducing the suctioned air into an H_2O mist with the latest improvements in this process; (3) improved drying kilns with special mention of American tunnel kilns and their advantages and economical factors and a laboratory muffle kiln for firing test pieces which is described; (4) a new German rotary muffle kiln with heating bodies of U-form constructed of quartz glass tubes; (5) a new kiln used for firing bathtubs; (6) adjustable charging devices for kilns; (7) an electrically heated metal supporting device to prevent too rapid cooling of newly fired enameled ware; a temperature of 300° is usually used, but higher or lower temperatures can be maintained; (8) repairing of damaged ware, *e.g.*, bathtubs, etc., with plastic cement which resists hot water. An American invention for restoring the glaze to etched enamel surfaces and other American innovations are described. M.V.C.

Less familiar elements in ceramic pigments. C. J. HARBERT. *Ind. Eng. Chem.*, **30** [7] 770–72 (1938).—H. describes the properties and uses of the following inorganic oxides as opacifiers and coloring agents: (1) white oxides, including titanium, zirconium, tin, cerium, and molybdenum; (2) coloring oxides, including vanadium, selenium, neodymium, praseodymium, and uranium. Illustrated. F.G.H.

Lithium oxide enamels highly resistant to acids as components of glazes and different opacifiers. LUDWIG STUCKERT. *Glashütte*, **69** [10] 172–74 (1939); translated in *Glass*, **16** [4] 139–40, 143 (1939).—In an antiacid enamel containing 24% KNaO, a part of the alkaline oxides was replaced by equivalent amounts of Li_2O to increase the resistance to acids. The results of these experiments are as follows: (1) alternating attack by acids and bases corroded the enamels more strongly than attack by acids alone; (2) enamels containing lithium are much more resistant to acids than those containing only Na_2O; this superiority persists even when this attack has been preceded by an alkaline attack; (3) concentrated alkalis attack enamels containing lithium more strongly than those without it, because lithium is less electropositive than sodium and, as a result, is less strongly bound to the silica; (4) if the Li_2O content attains 10% of the total alkalis, the attack by acids greatly diminishes, and with 14% Li_2O, it practically disappears; difficulties in melting or firing arise if more is used. The mat aspect of enamels after the attack and the influence of opacifiers such as cerium dioxide, tin oxide, and metantimonate of soda are discussed. The resistance to acids is conditioned much more by the content of lithium than by that of the opacifier, although the latter is not negligible and is reduced in the case of antiacid enamels. M.V.C.

Mechanism and efficiency of organic inhibitors during pickling of iron. WILLY MACHU. *Trans. Electrochem. Soc.*, **72**, 333–59 (1937).—Experimental proof is submitted to show that the electrochemical or overvoltage theory heretofore advanced to account for the action of inhibitors in pickling solutions does not hold. Results indicate that, due to adsorption, a film is formed over both the metallic iron areas and the oxidized or scaled areas. The practical success in the use of inhibitors, however, is due to the greater adsorption of inhibitor at the metallic areas than at the oxidized or scaled areas. Accordingly, since the time of diffusion of the acid ions through the inhibitor film will be longer, the greater the thickness of the film, the oxidized or scaled areas will be more readily attacked by the acid than the metallic areas. Illustrated. F.G.H.

Milling and its effect on some properties of porcelain enamel slips. R. L. FELLOWS AND J. L. MCLAUGHLIN. *Jour. Amer. Ceram. Soc.*, **22** [8] 260–64 (1939).

Observations on the function of adherence-promoting oxides in ground-coat enamels. KARL KAUTZ. *Jour. Amer. Ceram. Soc.*, **22** [8] 250–55 (1939).

Organic inhibitors of corrosion. CHARLES A. MANN. *Trans. Electrochem. Soc.*, **69**, 115–29 (1936).—A theory is presented which explains the mechanism of inhibitor action for organic inhibitors in the acid corrosion of steel. Organic inhibitors containing nitrogen, oxygen, or sulfur are considered. M. investigated aliphatic amines, aromatic amines, and heterocyclic nitrogen-containing compounds, the ketones (both aliphatic and aromatic), and a sulfur-containing inhibitor. All of these form the onium compounds which ionize readily. The length, the number, and the position of aliphatic radicals on rings and particularly their stereochemical arrangement determine the effectiveness of inhibition as well as the quantity of inhibitor required for good protection. Solubility and the resulting increasing ionization are requisites for good inhibiting action. Illustrated. F.G.H.

Oxide film between fired ground-coat enamels and iron. KARL KAUTZ. *Jour. Amer. Ceram. Soc.*, **22** [8] 247–50 (1939).

Pickling time. VIELHABER. *Beizerei* (in *Emailwaren-Ind.*, **16** [7–8]), **4** [2] 5–6 (1939).—Pickling time may be shortened by (1) rapidly stirring the bath or agitating the ware or (2) heating the bath of dilute H_2SO_4. M.V.C.

Relationship between the synthesis of white enamels and their cost and foreign exchange expense. ERNST RICKMANN. *Emailwaren-Ind.*, **16** [5–6] 23–28; [7–8] 41–44; [9–10] 64–65 (1939).—R. discusses the appearance and phenomenon of opacification with the commonest opacifier, *viz.*, fluoride, where mill-clay opacification, depending on gas opacification and solid opacifiers such as zinc oxide and antimony, is involved. In order to reach its highest effectiveness, every opacifier requires a very special synthesis of the enamel, and attention must be given to the presence of special materials. The effectiveness of different opacifiers in an enamel can not be determined in advance since two, three, or more actions which affect each other are concerned. Some combinations do not increase opacity. When only one opacifier is used, there is usually no simple relationship between the amount used and the opacifying action. It is not generally economical to try to increase opacifying action by adding large amounts of opacifiers. A better and cheaper way is to combine different opacifiers skillfully. It is unadvisable to apply the enamel thickly in order to get a good coat with low expenditure for opacifier; economy is obtained only in exceptional cases because the stability of the ware is endangered. Time and trouble are required to develop a highly efficient enamel in which the opacifier reaches its fullest action, but the cost and foreign exchange expense

can often be lowered and the value of the enamel increased. A thinly applied but well opacified enamel is preferred. M.V.C.

Scientific aspects of the pickling problem. E. HERZOG. Translated in *Wire & Wire Products*, **13** [4] 177–80 (1938); see *Ceram. Abs.*, **17** [4] 135 (1938). B.L.

Solvent degreasing. W. W. DAVIDSON. *Trans. Electrochem. Soc.*, **72**, 413–27 (1937).—The solvent-degreasing process for the removal of oil and grease from metal products prior to the application of various types of finish is described in considerable detail. Fundamental principles of equipment design and the characteristics of the stabilized noninflammable solvents are discussed. Illustrated. F.G.H.

Standardization by Porcelain Enamel Institute. ANON. *Bull. Amer. Ceram. Soc.*, **18** [7] 269 (1939).

Substitute materials in enamels. O. KRÜGER. *Emailwaren-Ind.*, **16** [3–4] 11–18 (1939).—Substitute materials for borax, antimony, and tin oxide in enamels and the economy obtained by their use are discussed. Superkryol, a borax substitute, has the following composition: 5.06 loss on firing, 0.90 H_2O, 41.48 SiO_2, 4.05 Fe_2O_3, 0.45 MnO, 2.50 ZrO_2, 13.58 Al_2O_3, 4.75 CaO, 3.52 MgO, 6.86 B_2O_3, 7.55 Na_2O, 4.70 K_2O, 2.98 F, and 1.88 TiO_2. A saving of 30% borax is obtained by the use of Superkryol and Haftgrund. Another substance which has been developed to replace a part of the borax content of enamels is an artificial silicate called Sioglur, a magnesium-calcium borosilicate for cover enamels and a calcium-magnesium-fluorborosilicate for ground enamels. Several batches for powder enamels for bathtubs are given which use (1) Greif, a white opacifying agent (kaolin); and (2) Leukopan C, a new opacifier with low antimony content whose good action is due to its Na_2KAlF_6 content. A table gives data for batches of powder enamels for bathtubs with different opacifiers and their relative cost. M.V.C.

Substitute materials for tin oxide and borax. H. LANG. *Glashütte*, **69** [10] 194–96 (1939).—Sodium phosphate, soda, potash, fluoride, and powdered glass can be used as substitutes for borax only when they are used in combination with each other. Sb and Ce are important substitutes for Sn but must be imported in Germany. M.V.C.

Use of inhibitors (with special reference to antimony) in the selective removal of metallic coatings and rust. S. G. CLARKE. *Trans. Electrochem. Soc.*, **69**, 131–44 (1936).—Inhibitors of the type represented by quinoline restrain the action of hydrochloric acid on a variety of metals, while antimony chloride is selective in its action, powerfully restraining the action of the strong acid on iron, nickel, and cobalt but markedly accelerating the dissolution of zinc, cadmium, tin, and chromium. This behavior may be made the basis of methods of quantitatively removing metals of the last-mentioned group when they are present as coatings on metals of the first group. Copper and brass show slightly greater attack in hydrochloric acid-antimony chloride solution than in hydrochloric acid alone, but, as the attack is slow, copper and brass may be included with metals of the first group for this practical application. Published processes in which antimony has been utilized as inhibitor have so far been described for zinc, cadmium, and tin as coating metals on iron and steel. The restraining action of antimony in hydrochloric-acid solution extends to low- and high-carbon steel, chromium steels, wrought iron, and gray cast iron; the efficiency was rather low with wrought iron and distinctly less with cast iron. The rate of attack on electrodeposited zinc and cadmium varied with the conditions under which the metals were deposited. The inhibiting action of antimony in hydrochloric acid is associated in the case of iron, and probably in cases of metals of similar electrochemical character, with the formation of a film of antimony, which, while cathodic to the metal, produces a surface of relatively high hydrogen overvoltage which renders difficult the evolution of hydrogen. With zinc, cadmium, tin, and chromium, the stimulation of attack may be caused by the deposited antimony facilitating hydrogen evolution by reason of the high e.m.f. of the antimony: metal couples and the relatively lower hydrogen overvoltage on the cathodes. Antimony inhibits the solution of iron only in relatively concentrated hydrochloric acid; in dilute hydrochloric or sulfuric acid, antimony deposits in a spongy nonprotective form. Hydrochloric acid can be used for the quantitative removal of rust provided that there are substances present to prevent attack on the metal. Antimony chloride is a suitable inhibitor, and stannous chloride should also be present to reduce ferric chloride which has a corrosive effect. The solution, used with vigorous agitation to increase the speed of rust removal and also to ensure adequate distribution of stannous chloride for reducing purposes, is rapid in action and effective. F.G.H.

PATENTS

Enameling cast-iron objects. WALTER ECKHOFF. Ger. 671,955, Feb. 2, 1939 (April 9, 1935); VI/48*c*. 1. Addition to 662,727 (*Ceram. Abs.*, **18** [1] 14 (1939)).—A primary layer of enamel is applied and dried until the luster on the surface caused by the water just disappears; an additional layer of enamel is then applied and fired. D.A.B.

Preparing enamels. KARL FRANK AND FRITZ OSTERLOH (I. G. Farbenind. A.-G. and Eisenwerk Kaiserslautern). U. S. 2,165,134, July 4, 1939 (Jan. 9, 1937).—A process of preparing enamels of a high resistance to variation of temperature comprises adding substantially pure silicic acid fused and then cooled to solidification to the components of the enamel, grinding the mixture, mixing it with water or a binding agent, fusing the enamel on the articles to be covered, and firing them at ordinary firing temperatures.

Producing silicate melts opacified with zirconium oxide. AUERGES. AKT.-GES. Brit. 507,823, July 5, 1939 (Sept. 14, 1937).

Truing iron for enamel operations. ELISABETH GOHL. Ger. 671,530, Jan. 26, 1939 (Oct. 9, 1937); VI/48*c*. 3.—A truing iron for enamel operations is provided with a heating unit. D.A.B.

White opaque vitreous enamel frit. IGNAZ KREIDL (Vereinigte Chemische Fabriken Kreidl, Heller & Co. Nfg.). U. S. 2,165,554, July 11, 1939 (Nov. 24, 1931; Dec. 5, 1936).—A vitreous enamel frit is made from cryolite-free raw materials containing silicates, borates, alkali metal compounds, and fluorides, the latter being introduced into the raw mixture by means of a fluosilicate so as to furnish about 10 to 12% fluorine by weight of the total weight of the raw mixture, and the ratio of alkali (Na_2O or K_2O) to boric acid being substantially greater than $1^1/_2$ parts of alkali to one part of boric acid, excluding the alkali content of the fluorine compounds, whereby the frit is rendered suspendible in water with a minimum amount of clay addition and without excessive grinding.

Zinc sulfide as a ceramic opacifier. R. W. HANNAGEN. U. S. 2,163,516, June 20, 1939 (May 1, 1936).—An improvement in the production of glazes, enamels, etc., which contain ordinary zinc sulfide as an opacifier consists in introducing zinc oxide into the glaze at some stage of its manufacture or application.

Glass

Apparatus employing Jena glass filter plates for filtration, extraction, and gas washes. P. H. PRAUSNITZ. *Chem.-Ztg.*, **63** [21] 185–88 (1939).—The use of gas separators with glass filters has already exerted considerable influence on the methods of pure technical chemistry in which the filter stone, etc., is being increasingly used for distribution of gases in liquids. Various types of filters are described and illustrated, such as mercury filters, automatic filters, extractors for solid materials, perforators, and apparatus for the distribution of gases into liquids. See "Jena—," *Ceram. Abs.*, **18** [6] 156 (1939). D.A.B.

Attempts to improve the chemical resistance of heavy

baryta glass. Ts. A. Ioffe. *Optiko-Mekh. Prom.*, **8** [2] 15–17 (1938).—Sb_2O_3 acts favorably on the purification and chemical resistance of glass. Sb_2O_3 introduced with surplus SiO_2 greatly increases the chemical resistance of the glass (30 times) provided that ZnO is not present in the batch; it also increases the Abbe factor but lowers n_D. The removal of ZnO from the batch, all other things being equal, greatly increases the chemical resistance and the Abbe factor (gamma = 60.0); the figure n_D and dispersion, however, are lowered. M.V.C.

Calculating the annealing of glass. A. N. Dauvalter. *Stekolnaya Prom.*, **15** [1] 23–27 (1939).—A series of equations for computing the annealing of glassware is dealt with. M.V.C.

Chemical resistance of window glass containing magnesium oxide. M. A. Bezborodov and A. A. Kuzmina. *Stekolnaya Prom.*, **15** [3] 20–23 (1939).—The effect of MgO and Al_2O_3 on the chemical resistance of window glass was studied in three series of glasses containing 0 to 3% MgO and 0.5 to 3.5% alumina. MgO introduced instead of calcium lowers the stability of glass without Al_2O_3; the presence of Al_2O_3, however, checks the unfavorable effect of Mg. The introduction of Al_2O_3 in amounts of 1.5 to 2.0% sharply improves stability. A greater amount of Al_2O_3 improves it slightly. The processes of destruction of glasses in service and storing were studied. The same glass shows different resistance when subjected to the action of water and to that of weak solutions of alkaline carbonates. M.V.C.

Colorimetric determination of iron in glass using thioglycolic acid. R. C. Chirnside and Celia F. Prichard. *Jour. Soc. Glass Tech.*, **23** [95] 26–35T (1939).—The colorimetric determination of iron in glass was investigated, using thioglycolic acid. Tests made to determine the nature and amount of interference caused by the various elements occurring in glass show that cobalt is the only one causing serious interference; when cobalt is present only in the small amount necessary for decolorizing, it causes no actual interference. For colored glasses, a preliminary separation of the iron with zinc oxide is recommended. Analytical details are given for the determination of iron in soda-lime-silica and alkali-lead oxide-silica glasses. The modifications necessary when using this method for colored glasses are also given. The method has been checked with other methods and with a series of standardized samples. G.R.S.

Controlling separation and segregation. Anon. *Ceram. Ind.*, **27** [5] 356–58 (1936).—Screen tests made at a glass plant show that control or elimination of separation and segregation of raw materials is highly desirable. Segregation of fine and coarse material occurs wherever raw materials are permitted to move by gravity or to slide or move over one another. This segregation principally takes place when materials are charged into a bin and when they are emptied from it. A consideration of methods of breaking up segregation tendencies led Garve (*Ceram. Abs.*, **16** [7] 214 (1937)) to reason that the introduction of a solid center core would check the flow of central material and permit the flow of outside material. Other suggested means of preventing separation and segregation are discussed. Illustrated. See "Segregation—," *ibid.*, p. 213. E.J.V.

Converting a producer gas fired tank for natural gas. James E. Dare. *Ceram. Ind.*, **32** [7] 31–33 (1939).—A glass tank was converted from producer to natural gas, using a low-pressure luminous flame method of firing. The following final changes were made: the ports were raised and sloped toward the tank, natural gas burner blocks were installed, a gas distribution system was installed, the producer gas valve was shut off, and gas burners were installed on feeders, lehrs, and forehearths to replace oil. The plant experienced a reduction of approximately 30% in rejects, average tank life was increased even though the melting rate was raised, and fuel costs per ton of glass melted were materially reduced, due mainly to more uniform temperature control. Conversion details, plan views of the tank, and operating data are included. L.M.C.

Decolorizing glass in a large tank furnace. V. P. Kirichenko. *Stekolnaya Prom.*, **14** [11] 3–5 (1938).—Attempts to improve decoloration of glass by lowering the sulfate content of the batch and decreasing and increasing the temperature of melting of the batch are briefly discussed. M.V.C.

Defects in finishing hollow art glass. A. Hübler. *Glastech. Ber.*, **17** [5] 129–33 (1939). J.F.H.

Density of some soda–potash–silica glasses as a function of the composition. John C. Young, Francis W. Glaze, Conrad A. Faick, and Alfred N. Finn. *Jour. Research Nat. Bur. Standards*, **22** [4] 453–64 (1939).—Data are presented on the density and composition of 194 glasses in the ternary system soda–potash–silica. A reproducible and consistent method of heat treatment is described which, when applied simultaneously to all the glasses, results in the cooling of each glass at the same rate through its own critical range as defined. A study of the data presented does not indicate that there is a simple relationship between specific volume and composition but that the relation is best expressed by a system of planes in a three-dimensional triordinate diagram whose intersections correspond fairly well to the boundary curves and eutectic compositions indicated by the equilibrium diagram of Kracek. The correspondence is very close for the soda-silica and potash-silica data, but it is only approximate for glasses containing all three constituents. Data on the specific volume of 10 lithia-silica glasses are presented graphically. R.A.H.

Different behavior of calcite and limestone in the glass melt. Anon. *Glashütte*, **69** [11] 209–10 (1939).—Lime is one of the raw materials of glass which is of uncertain action, as CaO is introduced in the batch in different forms, such as calcium hydroxide and calcined lime, which react differently. The question of when to use marble, limestone, or calcite in the glass batch is discussed. M.V.C.

Effect of ammonium concentration in silver solutions on the silvering of glass. B. N. Moskvin and A. A. Valov. *Optiko-Mekh. Prom.*, **8** [9] 14–16 (1938).—The concentration of ammonium in the solution when silvering with inverted sugar as reducer has a very great effect on the process of glass silvering. The concentration of ammonium must be known, as the change in the ammonium concentration in silver solutions influences the rate of reduction and the structure of the silver deposit. The greater the concentration, the larger is the grain structure of the silver lining formed. See *Ceram. Abs.*, **17** [5] 177 (1938). M.V.C.

Effect of annealing in a sulfur dioxide-containing atmosphere on the modulus of rupture of sheet glass. J. Boow and W. E. S. Turner. *Jour. Soc. Glass Tech.*, **22** [94] 357–71T (1938).—Specimens of sheet glass 10 cm. long, 0.85 cm. wide, and 0.274 cm. thick, with ground and mechanically polished edges, were heated at temperatures of 400°, 490°, 530°, 550°, and 580° for 2 hr. (in a number of cases, for additional periods), both in air and in an air-sulfur dioxide mixture. In both types of atmosphere, heating at temperatures of 490° to 580° resulted in an increase in mechanical strength as measured by the modulus of rupture, but the increase by heating in sulfur dioxide-air mixture was considerably greater than in air alone, *e.g.*, at 550° it was approximately 17% greater. Light films of sodium sulfate were formed on the glass in 2 hr. at 400° and 490°, and they increased rapidly with temperature between 490° and 580°. After the first film had been removed, a second treatment in sulfur dioxide-air mixture produced a second film of lighter character, the logarithm of the weight of this second film being inversely proportional to the reciprocal of the absolute temperature of treatment. G.R.S.

Effect of the chemical composition of glass and type of pigment used on the properties of selenium ruby. S. M. Brekhovskikh. *Stekolnaya Prom.*, **14** [12] 25–27 (1938).—B. studied the effect of replacing zinc by different oxides, replacing boric anhydride by other oxides, the quantity of alkaline oxides (Na_2O and K_2O), the quantity and composition of pigments, and cullet on the coloring of the glass and its behavior during melting. The increase of

zinc oxide content in the glass deepens the red coloring. Not less than 3% ZnO must be present for pressed glassware. Up to 10% boric anhydride deepens the red coloring of the glass; more than 10% will weaken it; B_2O_3 increases the transparency of the glass. All other conditions being equal, the replacing of K_2O by Na_2O in the glass weakens the red coloring. The glass may contain from 15 to 20% alkali. The addition of acetic acid as reducer stabilizes the burning up of pigments, and the addition of PbO in colloidal form as oxidizer is recommended. To change the glass coloring, the ratio of CdS to CdSe should be changed; increasing the Se yields dark red (raspberry) glasses; increasing the CdSe yields a light red (strawberry) color. The addition of cullet deepened the red coloring of glass in all cases. M.V.C.

Effect of steam on reactions of glass formation. Ts. A. Ioffe. *Stekolnaya Prom.*, **14** [11] 24–27 (1938).—The liberation of carbonic acid from the mixture $Na_2CO_3 + 3SiO_2$ is accounted for by a reaction between soda and silica, which is already noticeable at 650°. Steam considerably accelerates this reaction. The dissociation of soda in the air is very small at temperatures below 1000° but is accelerated in the presence of steam. A marked liberation of CO_2 from the mixture $CaCO_3 + 3SiO_2$ begins below 650°; with increasing temperature the rate of liberation increases. The volatilization of CO_2 from the mixture of $CaCO_3$ and SiO_2 is accounted for by the dissociation of $CaCO_3$ and to only a slight degree by the interaction of $CaCO_3$ and SiO_2. Steam accelerates the process of liberation of CO_2. The dissociation of $CaCO_3$ in the air proceeds at rather low temperature and may be ended at 800°; in the presence of steam, this disintegration of $CaCO_3$ is rapid. Reactions occurring in soda-lime glasses ($Na_2CO_3 + CaCO_3 + 6SiO_2$) may be completed at a temperature below 1000°, *i.e.*, essentially while still in the solid state. The heating of the batch in the presence of steam greatly accelerates the liberation of CO_2. The catalytic effect of water is especially sharp at temperatures between 650° and 750°. The formation of glass and devitrite crystals takes place at temperatures below 800°; with increased temperature their quantity increases. The effect of steam is similar to that of increased temperature; the reactions of glass formation proceed more intensively in its presence. M.V.C.

Equilibrium between ferrous and ferric oxides in glasses. N. E. Densem and W. E. S. Turner. *Jour. Soc. Glass Tech.*, **22** [94] 372–89T (1938).—A soda-lime-silica glass of the composition 75 SiO_2, 10 CaO, and 15% Na_2O was melted in an electric furnace at 1400° for 22 hr. Subsequently, a series of 26 glasses containing from 0.002 to 12.5% iron oxide expressed as Fe_2O_3 was prepared under precisely similar conditions. The maximum dissociation (36%) of the iron oxide occurred at a total iron oxide content of 0.04% Fe_2O_3 and fell steadily until it reached a nearly constant value of about 9% for iron oxide concentrations between 3 and 12.5%. The corresponding colors depended both on the degree of dissociation and on the total iron concentration, blue-green predominating up to 0.1% Fe_2O_3, green from 0.2 to 0.9%, and olive green from 1 to 2%; the colors were examined in rods 10 cm. long. Melting the glass containing 0.075% total Fe_2O_3 for 100 hr. in addition to 24 hr. and heating rods for 24 to 48 hr. at 500° to 600° produced no appreciable change in the iron oxide equilibrium or in the color. In a series of seven soda-silica glasses containing from 15 to 45% Na_2O, with total Fe_2O_3 constant at 0.075% and all melted for 22 hr. at 1400°, the ratio of ferrous to total iron oxide progressively dropped from 37.7 to 13.3% and the color passed from blue-green to green. Using E. Preston's (*Ceram. Abs.*, **18** [1] 18 (1939)) viscosity data for the soda-silica glasses containing from 20 to 35% Na_2O and 1% total Fe_2O_3, the ratio of ferrous to total iron oxide was practically constant. Four potash-silica glasses containing from 20 to 35% K_2O and 0.075% Fe_2O_3 reproduced results similar to those of the corresponding soda-silica glasses, both in degree of dissociation and in change of color. Although in four lithia-silica glasses containing from 10 to 25% Li_2O the ratio of ferrous to total ferric oxide fell with increase in alkaline content (much more rapidly than in the case of the soda-silica and potash-silica glasses), the color changes showed a complete reversal of those in the three other series investigated. The explanation of these phenomena is not yet apparent; it seems that, however, the chemical factors predominate over the physical in so far as dissociation of the ferric oxide is concerned, viscosity apparently being relatively unimportant, and that, in particular, the basic or acidic character of the glass is important. An observation of special interest related to the influence of composition on the color is that in the three series of alkali-silica glasses, a sharp change of color was observable at glass compositions corresponding to lithium disilicate, sodium disilicate, and potassium tetrasilicate. G.R.S.

New silica glassware. Anon. *Bull. Amer. Ceram. Soc.*, **18** [7] 270–71 (1939).—A new method of glass manufacture yielding products which can be heated to cherry-red heat and then plunged into ice water without breaking has been developed in the research laboratory of Corning Glass Works. Articles made by this process shrink to less than $^2/_3$ their original volume yet suffer no distortion of form. The process consists of a series of contrasting operations: a normal glass object made with a special formula is leached with dilute nitric acid, treated further with heat, and on final heat-treatment shrinks to a transparent homogeneous state in which it is practically 96% pure silica. A technical description of the manufacturing process is given, and a comparison of the physical properties of the new glass, previous low-expansion glass, and fused quartz is included.

Glass blowing and properties of chemical glassware. R. G. Aickin. *Jour. Proc. Australian Chem. Inst.*, **6**, 68–78 (1939); *Chem. Abs.*, **33**, 4081 (1939).—Devitrification of glass due to crystallization of complex silicates and loss of Na oxide through chemical action is corrected by the addition of oxides of K, B, Al, and Zn. The composition and properties for 9 common glasses are given. The water-vapor film adsorbed by fresh blown glass is unimolecular. With age, the film becomes polymolecular. Pinholes in joints of vacuum apparatus, both glass-to-glass and metal-to-glass joints, are determined with the use of a Telsa coil. Precautions and instructions are given for the simple glass blowing of different glasses.

Glass in chemical engineering. R. Quarendon. *Glass*, **16** [5] 190 (1939).—During recent years, the use of glass in plant construction has shown a decided increase. Its light weight and resistance to attack by most chemicals make it a particularly desirable construction material. Tubing 15 ft. long and $4^3/_4$ in. in diameter is now produced and used for pipe lines carrying corrosive chemicals and foodstuffs. Heat exchangers, heating coils, and condensers are increasingly being constructed of glass. Glass vessels are made up to 80 liters capacity. In the construction of glass-lined equipment, certain precautions must be taken in its design, and only the best quality open-hearth steel containing not more than 0.15% carbon should be used. The vessels should have a uniform thickness of not more than 1 in. Glass textile materials (filter cloth), glass insulation, etc., are also used extensively. B.C.R.

Glass electrode for p_H determination, its particular features and practical importance. S. A. Strelkov. *Zavodskaya Lab.*, **8**, 36–48 (1939).—A review is given. 38 references. P.B. & E.S.

Glass as a material of construction. H. Ebert. *Glas & App.*, **19** [5] 45–46; [6] 59–61 (1938).—E. gives the applications of glass in physics, electricity, vacuum technique, lighting, architecture, furniture, the food industry, and for insulation, etc. F.E.V.

Glass research. Anon. *Chem. Age* [London], **40** [1042] 454–55 (1939).—The new buildings of the Department of Glass Technology of Sheffield University are described. Illustrated. A.B.S.

Glassmaking in Belgium. R. Jacquemin. *Times Trade & Eng.*, **45** [904] 24 (1939). A.B.S.

Grinding the surface of optical glass with hydrofluoric acid. V. Balakov. *Optiko-Mekh. Prom.*, **8** [12] 17 (1938).—The surface of the glass is coated with a thin

coat of wax or paraffin, with the exception of the places which have to be ground, and immersed into a weak solution of hydrofluoric acid. The depth of grinding depends on the length of treatment. M.V.C.

History of plate-glass manufacturing and of Captain John Baptiste Ford. ANON. *Bull. Amer. Ceram. Soc.*, **18** [7] 262–67 (1939).

How stained glass is made. N. W. GREGORY WALKER. *Discovery*, [N.S.] **2** [13] 163–69 (1939); *World Digest*, **1** [3] 69 (1939).—The art of making stained glass is fundamentally the same today as it was in the 12th century. There are no lost secrets; any glass known to medieval craftsmen can be reproduced today. Two main improvements in production are the gas oven, for firing the painted glass, and the cutting wheel. Under the old system of firing, the heating was uncertain, lasted 24 hr., and spoiled hours of labor. The modern process is a matter of minutes, and the glass is always on view through a small window. The medieval craftsman had no diamond, but split his glass with a hot iron. Sometimes he got the split where he wanted it but at other times his work was ruined; a cutting wheel, however, is reliable. Following immemorial practice the molten glass is blown into a bubble, is lengthened, and the ends are cut off to form a cylinder. After being cracked down one side, it is resoftened so that it may be opened out. A solid ruby or blue glass, if blown, would show almost black. A lump of white glass is therefore dipped into ruby or blue, so that, when blown, the color is only a film. Besides being translucent, these flashed glasses of different colors may be treated with acid so that they can be shaded down to white or to give a desired pattern, *e.g.*, diaper work or foliage. The colors are due to oxides, chiefly those of iron and copper and uranium and cobalt. The most precious glass made—a particular red—is colored with gold. A red from selenium is a modern discovery. Copper normally gives a range of blues and greens, but may be made to yield a ruby. Only one oxide will stain glass after it is made, *viz.*, silver, which gives a permanent yellow. This 14th century discovery, by giving glassworkers a color to paint with, went far toward spoiling glass staining, for the cheap effects of the new technique were badly abused. In making a window, the artist first makes a sketch, usually on the scale of an inch to a foot, which is enlarged into a cartoon, showing the window full-size. Next an outline is made showing nothing but the position of the lead strips, the breadth of the lines being that of the cores of the leads apart from their flanges which will overlap the edges of the glass. The cutting is done on the guide given by the outline and is nearly always done with a wheel. The downward pressure of the wheel starts a crack which the craftsman deepens by tapping the underside and the glass almost falls apart. Deep curves must be taken out in small pieces, either with the aid of pliers or the grozing iron which catches the glass in a slot and snaps it off. The pieces of glass are reassembled on a sheet of plain glass and stuck to it with a dab of hot wax at their corners. The window is set upright on an easel with the light passing through and is then ready for painting which consists in filling in features and other detail and any shading required. The pigment used, of one color only, is made of powdered glass melted and combined with an oxide of copper and iron. It may be so deepened as to become black and opaque. Shading is usually done by laying a wash of pigment (a mat) and brushing this down or hatching through it with a tool. The painted pieces go to the oven where they are heated to 400° to 500°C, at which temperature the pigment sinks into the glass of which it becomes a part. At any stage of the painting a piece may be detached from the easel and fired or refired until the artist is satisfied with it. The pieces are then laid on the outline and set into lead strips which are soldered at every joint with an electric iron. Cement is worked under the flanges to make the window watertight, and copper wire is soldered to the lead, ready for twisting around the bars that brace the window. A.B.S.

Increase capacity of day tank 57% by remodeling. J. B. NEALEY. *Ceram. Ind.*, **28** [1] 88–90 (1937).—Using fused cast tank block and an interlocking arch of silica brick to rebuild a tank with the regenerators even with the furnace resulted in an increase in capacity from $3^1/_2$ to $5^1/_2$ tons with a fuel consumption reduction of 80,000 cu. ft. of natural gas per week at the Pittsburgh Reflector Co., Irwin, Pa. E.J.V.

Influence of rare earths and their derivatives in glass on the double color play and ultraviolet absorption of glasses. V. ČTYROKÝ. *Glashütte*, **69** [17] 305–306; [18] 320–25; [19] 337–40 (1939); see *Ceram. Abs.*, **17** [11] 350 (1938). M.V.C.

Invisible glass. H. L. *Discovery*, [N.S.] **2** [13] 182 (1939).—Invisible glass is made by coating the glass with a film which reflects the light from the outer surface with an intensity equal, but opposite in phase, to the ray reflected from the glass-film surface. No light is then reflected. The films are of cadmium arachidate. A.B.S.

Is acid etching of glasses with very high silica content possible? BRUNO SCHWEIG. *Glass*, **16** [5] 189 (1939).—S. attempted to produce a fine satin finish inside of bottles made from glass of especially high silica content such as Hysil which is similar in composition to Pyrex-brand glass, Sibor, Jena-Duran, Nonex, etc. Hysil glass has the following composition: silica 80, boric acid 13, alumina 0.75, and soda 6.25%. Although no method was discovered that gave the desired results, the most promising results were obtained with the following mixtures: (*a*) 45 g. concentrated hydrofluoric acid and 25 g. powdered ammonium bifluoride and (*b*) 5 g. sodium hydroxide, 10 g. water, and 15 g. ammonium bicarbonate. Mixture *b* was added in small amounts to *a*, and, when effervescence ceased, it was poured into the bottles to be etched. A reaction temperature of 65°C maintained for 15 min. gave an even mat, but the grain was too large for the satin finish desired. B.C.R.

Manufacture of safety glass. H. G. WICE. *Jour. Record Trans. Junior Inst. Engrs.*, **48**, 532–39 (1937–38).—W. discusses the early history of safety glass and the events leading to its early adoption for use in motor vehicles. The method of manufacture of laminated glass is outlined. The principal tests used are (1) the impact test, in which a 2 lb. steel ball is dropped from a height of 4 ft.; (2) the light test, in which the glass is exposed for 500 hr. at a distance of 9 in. from a mercury arc lamp and at a temperature of 120° to 140°F; no discoloration should result; and (3) the heat test, in which the glass must show a resistance to bubbling and blistering after boiling for 8 hr. B.C.R.

Mechanism of dielectric losses at low temperatures in glasses containing admixtures of metallic ions. E. E. LYSENKO. *Zhur. Tekh. Fiz.*, **8** [18] 1637–41 (1938).—Experimental results on dielectric losses at low temperatures in glasses containing admixtures of metallic ions are not in agreement with those determined on the basis of the Frenkel theory which claims that the metallic ion gives the energy of its vibrations to the glass particles and in this way disseminates the energy of the outer field. B.Z.K.

Modern construction details in a windowless plant. ANON. *Mill & Factory*, **24** [5] 68–71 (1939).—The largest area of glass block in any plant in America is in the Industrial Rayon Corp. plant at Painesville, Ohio. Over 371,000 glass blocks comprise the glass installation in this completely air-conditioned windowless structure. Illustrated. D.A.B.

Modern glass industry. P. GILARD. *Chimie & Industrie*, **40** [6] 1051–59 (1938).—G. gives a historical outline of the glass industry and reviews recent development of the different products including window plate, safety, lead, crystal, flint, bottle, optical, silica, chemical, multicellular, structural, and lighting glass, selective glass for given radiations, and glass wool. The actual problems are briefly sketched. F.E.V.

Mole volumes of glasses. W. BILTZ AND F. WEIBKE. *Keram. Rundschau*, **46** [51] 600 (1938).—A criticism of O.

Knapp (*Ceram. Abs.*, **18** [1] 17 (1939)) is answered with an example. F.E.V.

Mosaic structure of silicate glasses. N. A. SHISHAKOV. *Zhur. Tekh. Fiz.*, **8** [15] 1347–55 (1938); *Tech. Phys. U.S.S.R.*, **5**, 666–75 (1938).—By analogy with the phenomena observed in the peptization of some silicate powders, S. attempts to show that silicate glasses have a mosaic structure. The empty spaces between the closely packed particles are claimed to be responsible for some of the properties of the glasses. Approximate calculations show that the linear sizes of the elementary mosaic particles in glasses are about 700 Å and the width of the empty spaces between them is about 12 Å. B.Z.K.

New polarization filter for testing tensions in glassware. M. HASSE. *Glashütte*, **69** [9] 145–48 (1939).—The action of the new filter is based on the dichroism of crystal tourmaline. Tourmaline has been used before for polarization purposes for selecting color variations. In one direction in the plate the light is strongly absorbed, and in the perpendicular direction, the light polarized rectilinearly through the crystal is let through. The tourmaline tongs of Seebeck constitute the first primitive tension examiner. A transparent object with double refraction or tension is properly placed between crossed polarizers; the stresses show up dark. Herapathite crystals (quinine sulfate periodide) have the same dichroitic properties as tourmaline. New polarization spectacles are described, and further uses of polarization filters for microscopes and photographic apparatus are discussed. M.V.C.

Nickel in glass manufacture. D. R. W. MÜLLER. *Allgem. Glas- & Keram. Ind.*, **29** [12] 1–2; [14] 1–2 (1938).—M. gives considerations on stainless and heat-resisting alloys used in glass manufacture. Cast iron containing up to 3% Ni stands heat better than common cast iron but can not properly be called a heat-resisting alloy. Austenitic iron combined with 14% Ni, 3 to 5% Cr, and 7% Cu or associated with 18 to 20% Ni, 3 to 4% Cr, and 4 to 7% Si resists oxidation up to 800°C. Wrought or cast austenitic steel containing up to 35% Ni and 30% Cr stands corrosion up to 1050°C. Sulfur dioxide especially is detrimental to these alloys. The alloys are used for overflow spouts for delivering glass to the forming machine, for gas dampers and reversing valves which are liable to be damaged during soot-burning operations, and for heat exchangers for recuperators, molds, etc. Early molds used in glass manufacture were made of cast iron or high-grade ingot iron; they did not give good service because of crizzles which developed in the metal causing the molten glass to stick on the mold. Cast iron suitable for making molds has the formula C 2.8 to 3, Si 1.5 to 2, Mn 1.5 to 2, Ni 14 to 15, Cr 3 to 3.5, and Cu 0 to 0.5%. American molds made of similar alloys may be operated for 40 hr. without requiring any rubbing or cleaning (brushing), a period of time ten times longer than that permissible with ordinary cast-iron molds. Small phials for perfume are made in molds composed of 80% Ni + 20% Cr. In France and England, bottle molds are made of a Ni-Cr alloy containing 60% Ni and 2% W (tungsten); this alloy shows no points of transformation; molten glass does not stick on the polished surface of these molds which supply 40 times the quantity of glass articles obtainable with a mold made of the best cast iron. The brilliancy of the finished product is comparable with that of cut glass. R.W.D.

Painting on sheet glass and satin glaze painting. ZSCH. *Glashütte*, **69** [15] 273–75 (1939).—The technique of stained glass manufacture is described. In making mosaic glass, the colors are fired in the glass itself and the different colored glass fragments are held in place with lead strips. Stained glass made in this way does not deteriorate in color with time. In cabinet glass painting, large pieces of glass of superior quality to the antique glass, which of necessity contained bubbles, seeds, and streaks because of the primitive working conditions, can be used; whole or parts of pictures can be painted directly on the glass with glass pigments which are then fired. This type of stained glass is also stable. In painting in oil on the back of panes of glass, the type of colors used are damaged by dampness and weathering; a protective lacquer coating must, therefore, be applied. In satin glass painting, a layer of an easily fusible colorless or colored coat containing lead is applied to one side of a thin pane of window glass and fused on. This gives a silklike mat sheen. The technique of manufacture is given in detail. M.V.C.

Physical property-temperature relationships; their bearing on the nature and constitution of glass: I, Viscosity. E. SEDDON. *Jour. Soc. Glass Tech.*, **23** [95] 36–72T (1939).—The variation of viscosity over wide ranges of temperature is studied for glasses having varying degrees of complexity and for comparison materials of known internal structure, such as water, molten salts, molten or liquid metals, alcohols, and paraffins, as well as other organic liquids representing simple molecular types. Values for the group-binding energy, E_η, and the term regarded as being connected with effective particle size, $r_0'/\alpha\delta^2$, are derived for each of the above glasses and comparison materials at varying temperatures using the theoretically derived viscosity-temperature equation of Frenkel modified by S. to suit conditions of changing cluster size. The data derived enable conclusions to be reached regarding the internal structure of substances in the vitreous state. G.R.S.

Producing glasses without alkalis and their properties. M. G. CHERNYAK. *Stekolnaya Prom.*, **14** [12] 30–31 (1938).—Experiments show that it is possible to produce alkali-free glasses of sufficient stability with respect to crystallization and working facility. The properties of these glasses are shown in tables. M.V.C.

Production analysis for mold making in glass plant. GEORGE ROESSLER. *Ceram. Ind.*, **27** [6] 419–22 (1936).—To obtain maximum production from mold-shop equipment an analysis should be made, by operations, of the production of each mold part, listing the operations at each step for each type of piece and the tools needed for that step and the following steps. In this way, the system of duplicate parts manufacture is applied to mold making. Details of production of various parts of molds are given. E.J.V.

Progress through coöperation. History and development of laminated safety glass. EDWARD R. WEIDLEIN. *Ind. Eng. Chem.*, **31** [5] 563–66 (1939); see *Bull. Amer. Ceram. Soc.*, **18** [4] 153; [5] 176 (1939). F.G.H.

Seed in glass melted in tank furnaces. J. B. MURGATROYD. *Jour. Soc. Glass Tech.*, **23** [95] 5–16T (1939).—Possible sources of seed in glass are (1) gases resulting from the melting batch, (2) entrapped air in the batch, and (3) gases from porous refractory materials. Possible sources of boil are (1) dissolved gases coming out of solution, (2) reaction between glass constituents, and (3) reaction between glass and some agent in the refractories or some foreign matter. In carbon-amber glasses there is a strong tendency to boil when reheated, not necessarily to a higher temperature than that of original melting, and the boil may be associated with reaction between the carbon and residual sulfate. The reaction between batch constituents is the least likely cause of seeds, for quite small particles of batch give rise to large bubbles of carbon dioxide. Entrapped air and moisture are regarded as the most likely sources of small seeds, and calculations show the possibility of introducing about 1000 seeds of 0.08 mm. diameter into 1 cc. of glass and a still greater number of small seeds. Even a fairly dense well-fired refractory may be the source of seeds in glass, with the possibility of introducing 280 seeds of 0.075 mm. diameter into 1 cc. of glass and others from pores of smaller diameter. The risk is particularly increased when refractories of fairly high porosity are employed at the working end of a tank furnace. The methods of calculation and procedure for determining seeds in glass are described. G.R.S.

Self-hardening as a method for increasing the strength of glass. I. I. KITAĬGORODSKIĬ. *Compt. Rend. Acad. Sci. U.R.S.S.*, **19**, 711–14 (1938).—Laboratory tests with glasses of different composition proved the correctness of

the principle of obtaining glass of a good mechanical strength by fritting and subsequently air-cooling two or more layers of glass having closely approaching coefficients of thermal expansion but being characterized by different hardening rates. The glasses obtained in this way showed characteristics similar to those of Securit glass in respect to impact strength and the appearance of fragments when broken. Colored glasses can be obtained in the same way by combining colored and uncolored layers. The method can be applied to finished glass and to glass in the process of manufacture. A further improvement can be attained by additional cooling. P.B. & E.S.

Silumin and its technology. V. M. Plyatskiĭ. *Optiko-Mekh. Prom.*, **8** [6] 11–15 (1938).—Silumin is a eutectic melt of alumina and silica containing about 12% SiO_2, and it is used extensively in the optical industry. Its manufacture, working, and properties are dealt with. M.V.C.

Standard glass batches. L. Springer. *Glashütte*, **69** [18] 319–20 (1939).—Unnecessary experimentation with glass batches, raw materials, and costs can be avoided in the glass industry, especially in mass production, by adopting a standard unit batch composition for every type of glass. A standard batch composition is given for soda-lime glass, potash-lime glass, potash-lead glass, lead-crystal glass, and medicine glass. M.V.C.

Strength of glass fiber. F. O. Anderegg. *Ind. Eng. Chem.*, **31** [3] 290–98 (1939).—The strength of glass is reduced by discontinuities but, by thorough melting and proper methods of attenuation, the effect is greatly reduced so that strengths of 400,000 lb./sq. in. are being produced commercially with fine fibers for textiles. Generally, the finer the fiber, the greater is the strength, the discontinuities apparently being pulled out lengthwise. The strength may be summarized from the bulk strength plus corrections for the decreased cross section. The scatter in strength results of such material as glass is considerable, resulting from the variations in the number and in the severity of discontinuities. The shorter the fiber tested, the higher are the average results. The breaking is probably also affected by thermal energies which vary from atom to atom. Glasses low in alkali or entirely free from it have extremely high electrical resistance and stand up well to repeated wetting and drying. On the other hand, glasses containing alkali seem to withstand most acids quite well. Fused silica has yielded strengths as high as 3,500,000 lb./sq. in. Illustrated. F.G.H.

Theory of the glass electrode: II, Influence of boric acid anhydride and aluminum oxide on the electrode properties of glass. B. P. Nikolskiĭ and T. A. Tolmacheva. *Zhur. Fiz. Khim.*, **10**, 504–12 (1937).—The authors investigated the dependence of the potential of the glass electrode on p_H when NaOH is added to water for the following glasses: (*a*) McInnes-Dole glass, (*b*) glass containing about 9% boric anhydride, and (*c*) glass containing 6.7% Al_2O_3. In (*b*) and especially in (*c*) greater deviations from the hydrogen electrode function which begins at lower p_H values are evident. The presence of sesquioxides hampers the exchange of sodium ions contained in the glass with hydrogen ions from the solution. The curves obtained qualitatively confirm the appearance of the sodium electrode functions of glass electrodes at high p_H values. Lithium ions have the same effect as sodium ions on all glasses. Potassium electrodes have a small influence on the electrode potential in (*a*) and a greater influence in glasses containing sesquioxides. A preliminary period of the glass electrode in a KOH solution leads to an afteraction of potassium ions, sodium ions exerting less influence on the electrode than usual. This effect can be overcome only after prolonged treatment with HCl acid. Ba ions have almost no effect on the potential of glass electrodes. **III, Transition of the hydrogen function of the electrode into that of sodium.** *Ibid.*, pp. 513–23.—An experimental study of the dependence of the potential of glass electrodes prepared from glasses of different compositions (silicate, borosilicate, and aluminosilicate) on the activities of H and Na ions in the solution in a wide range of concentrations confirmed in general the theory previously presented. When the p_H of the solution increases in the presence of sodium or lithium ions, the glass electrode changes the hydrogen function to the sodium or lithium function. This change takes place the more easily, the more firmly Na or Li ions and the more feebly H ions are bound in the glass. The relation between the values of this bond is expressed by the constant of equilibrium and free energy change, $\Delta\Phi_0 = -RT \ln K$; the relative firmness of bond of the H ion in glass and its bond in the solution is much higher than the firmness of bond of the sodium ion in glass and its bond in the solution. The introduction of B_2O_3 and especially of Al_2O_3 lowers this difference. To determine the constant, K, on the basis of potential measurements of the glass electrode, three methods based on the above theory have been developed; they give equal results, thus confirming the correctness of the theory. For Part I see *Ceram. Abs.*, **17** [8] 292 (1938). P.B. & E.S.

Use of cobalt by glassmakers of the Middle Ages. W. Ganzenmüller. *Glastech. Ber.*, **17** [5] 133–38 (1939). J.F.H.

Use of heavy spar for introducing barium oxide into glass. L. M. Blyumen. *Stekolnaya Prom.*, **14** [11] 8–10 (1938).—Large deposits of $BaSO_4$ but little $BaCO_3$ are found in Russia. Glasses were melted without difficulty and easily refined; no traces of devitrification were found. These glasses are softer than ordinary lime glasses and, therefore, are more easily worked. They also have a good luster but are difficult to decolorize. M.V.C.

Using fluorescence to determine striae in glass. M. A. Bezborodov and N. O. Abelchuk. *Stekolnaya Prom.*, **14** [8–9] 38–39 (1938); translated in *Jour. Soc. Glass Tech.*, **23** [95] 73–75T (1939).—A number of glasses of various compositions were analyzed with respect to striae and transparent stones present in them. The photoluminescence, also called fluorescence, method was used. The results are shown in tables. The observations show clearly that the fluorescence method permits a clear distinction between aluminous and siliceous striae; hence it will be possible to diagnose correctly the appearance of striae and transparent stones. M.V.C. + G.R.S.

Variation with temperature range of the resistance of glass containers to thermal shock. E. D. J. Robertson. *Jour. Soc. Glass Tech.*, **23** [95] 17–25T (1939).—Some of the methods employed in processing containers for potted meat, fish paste, etc., are noted, and a routine test for the thermal endurance of such containers is described. During the application of a modification of the standard test it was observed that, for the same downward thermal shock, the higher the temperature zone of the test, the greater are the breakages. For the same downward thermal shock in the same temperature range, breakage was found to decrease with increase of transfer time from 4 to 9 sec. The thermal endurance of a container could be largely improved by equalizing the wall thicknesses. A standard downward shock test of 95° to 40°, with a transfer time of 4 sec., was suggested for determining the thermal endurance of meat and fish-paste containers. G.R.S.

Woven glass yarn for better insulation is feature of portable welder. Anon. *Can. Machinery*, **50** [6] 93 (1939).—Woven glass yarn is used for transformer windings of a new portable welder. The mechanical characteristics are not affected by increase in temperature until the yield point is reached (500° to 600°C). Greater protection is given in cases of heavy overloading. D.A.B.

PATENTS

Apparatus for:

Applying mirror surfaces to the interior of lamp bulbs. M. E. Macksoud (Birdseye Electric Co.). U. S. 2,164,332, July 4, 1939 (Aug. 18, 1937; Nov. 18, 1937).

Bending vitreous rods or tubing. British Thomson-Houston Co., Ltd. Brit. 507,734, July 5, 1939 (Nov. 18, 1937).

Drawing sheet glass. Pierre Bertrand (Pittsburgh

Plate Glass Co.). U. S. 2,164,048, June 27, 1939 (Sept. 27, 1937).

Feeding molten glass. J. H. Thomas and Ed. Fletcher (Owens-Corning Fiberglas Corp.). U. S. 2,165,318, July 11, 1939 (Dec. 26, 1935).

Making glass sheets by drawing. Continentale Glasfabricatie Mij. Fr. 835,568, Dec. 26, 1938; *Chem. Abs.*, **33**, 4754 (1939).

Manufacture of glassware. Keni-Owens Machine Co. Brit. 505,965, June 1, 1939 (Nov. 2, 1936); divided out of Brit. 503,921, April 26, 1939.

Apparatus and procedure for severing and delivering molten glass. F. L. O. Wadsworth (Ball Bros. Co.). U. S. 2,164,184, June 27, 1939 (May 22, 1934; May 29, 1937).

Articles of vitreous quartz and process for producing and working. F. Skaupy and G. T. Weissenberg. Brit. 508,013, July 5, 1939 (Dec. 19, 1936).

Barite or lime-soda glass. I. F. Karpov, N. N. Kuleshov, and G. Yu. Zhukovskiĭ. Russ. 50,987, April 30, 1937; *Chem. Abs.*, **33**, 4754 (1939).—The resistance to friction is increased by introducing up to 10% ZnO and B_2O_3 into the barite glass mixture and increasing the Al_2O_3 content in the lime-soda glass up to 12 to 13%.

Blow or finishing molds for glass-shaping machines. United Glass Bottle Manufacturers, Ltd., F. A. Harrison, and H. P. Young. Brit. 507,828, July 5, 1939 (Oct. 25, 1938).

Drive for the conveying rollers of a machine for producing a continuous width of ground and polished glass. Frederic Waldron, Granville Baillie, and Patrick Hogg (Pilkington Bros., Ltd.). Ger. 673,305, March 2, 1939 (March 15, 1938); XII/67*a*. 15.—The entire equipment consists of a trough for the molten glass, a glass sheet producing apparatus, an annealing furnace, and an apparatus for grinding and polishing the glass width in which the width is worked simultaneously from both sides; the glass width, after its formation, is conveyed to the annealing furnace (at a definite speed which can be regulated) and sent between the working tools of the apparatus for the grinding and polishing by means of conveying rollers which grasp it. The glass is conveyed at a speed which is less than the speed of the glass width leaving the annealing furnace. The conveying rollers are driven in such a manner that the circumference speed of all rollers is equal to the speed of the glass width, independent of the differences in the rotation speed of the rollers which are traced back to unintentional diameter variations. D.A.B.

Electric heating of glass. Soc. Anon. des Manufactures des Glaces & Produits Chimiques de St. Gobain, Chauny & Cirey. Brit. 506,696, June 14, 1939 (June 15, 1937).

Electric lamp. Heinrich Asmussen (Canadian General Electric Co., Ltd.). Can. 381,672, May 30, 1939 (Aug. 26, 1936). G.M.H.

Filaments or bands of quartz or similar material. Franz Skaupy and Gustav J. Weissenberg. Fr. 835,428, Dec. 21, 1938; *Chem. Abs.*, **33**, 4754 (1939).—Molten quartz is fed to the draw plate at a much lower rate than that of drawing, and the cross-sectional area at the point of drawing is much larger than that of the filament to be obtained. The reduction in cross section is effected by the high speed of drawing.

Form for casting large glass objects. Corning Glass Works. Ger. 673,795, March 9, 1939 (Feb. 18, 1936); VI/32*a*. 7.—A form for casting large glass objects is provided with a base, upright side walls, and ceramic cores which stand upright on the base with a spacing between the core members and the side walls. The cores are porous and are attached in the form by flexible anchoring attachments. D.A.B.

Frosting glass by scarring. Karl Duldner and Roman Wadelka (Canadian General Electric Co., Ltd.). Can. 381,536, May 23, 1939 (Nov. 9, 1937). G.M.H.

Gas-tight seals whereby electric conductors pass into a vitreous envelope. General Electric Co., Ltd., R. L. Breadner, and V. J. Francis. Brit. 506,562, June 14, 1939 (March 25, 1938).

Glass ash furnace. Soc. Continentale d'Appareils Mécaniques pour la Verrerie Soc. Anon. Ger. 673,501, March 2, 1939 (Dec. 28, 1936); VI/32*a*. 5.—A glass ash furnace has a front wall in the shape of a polygon, and several installations or niches are recessed into the sides of the wall as places for removing glass from the glass tanks. The niche for withdrawing the glass from the mobile tank and the parts of the masonry or walling are constructed as self-dependent building units which are independent of the other walls surrounding the furnace. D.A.B.

Glass bottle and jar forming machine. T. F. Pearson (Crown Cork & Seal Co., Inc.). Can. 381,691, May 30, 1939 (Nov. 21, 1936). G.M.H.

Glass bottle-making machines. H. C. Daubenspeck and T. B. Kitson. Brit. 506,499, June 14, 1939 (Aug. 27, 1937).

Glass building block. John H. Fox (Pittsburgh Plate Glass Co.). Can. 381,578, May 23, 1939 (May 9, 1938). G.M.H.

Glass composition. Kitsuzo Fuwa and Fujio Suzuki (Canadian General Electric Co., Ltd.). Can. 381,534, May 23, 1939 (Sept. 16, 1936). G.M.H.

Glass feeder. E. J. Rush. U. S. 2,165,873, July 11, 1939 (June 30, 1938).

Glass-handling apparatus. William Owen (Pittsburgh Plate Glass Co.). U. S. 2,164,077, June 27, 1939 (July 19, 1938).

Glasses with high refractivity. Ernst Kordes. Ger. 673,797, March 9, 1939 (Dec. 22, 1936); VI/32*b*. 1.—Glasses with high refractivity consist of a basic mixture of lead borate (compounded with about 0.7 to 1.7 moles of lead oxide to 1 mole of boron trioxide) in which oxides of heavy metals having acid characteristics, such as titanium, tungsten, molybdenum, and vanadium, are dissolved either singly or in a mixture and, if necessary, in union or in chemical combination with one or several basic heavy metal oxides such as zinc oxide, cadmium oxide, etc. D.A.B.

Hollow-glass articles made from preformed parts and method and apparatus for making. Corning Glass Works. Brit. 507,387, June 28, 1939 (Aug. 12, 1937).

Hollow glassware forming machine. T. F. Pearson (Crown Cork & Seal Co., Inc.). Can. 381,544, May 23, 1939 (Sept. 8, 1937). G.M.H.

Incandescent electric lamp. Wilhelm Dunkel (Canadian General Electric Co., Ltd.). Can. 381,669, May 30, 1939 (Feb. 26, 1936). G.M.H.

Joining glass block sections. L. D. Soubier (Owens-Illinois Glass Co.). U. S. 2,164,093, June 27, 1939 (July 2, 1936).

Laminated safety glass. G. B. Watkins (Libbey-Owens-Ford Glass Co.). U. S. 2,164,301, June 27, 1939 (May 9, 1936).

Lehr drive for sheet glass machines. D. R. Limbers (Pittsburgh Plate Glass Co.). U. S. 2,164,071, June 27, 1939 (Sept. 29, 1937).

Lens. G. H. Aklin and F. E. Altman (Eastman Kodak Co.). U. S. 2,165,328, July 11, 1939 (April 16, 1938).

Machines for forming hollow glassware. E. G. Bridges. Brit. 508,056, July 5, 1939 (Nov. 30, 1937); divided out of 508,021 (see this issue).

Making vacuum-tight connections between ceramic bodies and other ceramic or metal bodies. British Thomson-Houston Co., Ltd. Brit. 506,520, June 14, 1939 (Nov. 30, 1936).

Manufacture of hollow glassware. E. G. Bridges. Brit. 508,021, July 5, 1939 (Nov. 30, 1937).

Manufacture of laminated safety glass. G. B. Watkins and D. H. Goodwillie (Libbey-Owens-Ford Glass Co.). U. S. 2,163,648, June 27, 1939 (May 9, 1936).

Means for treating hard surfaces. Georges Monnet (Soc. Anon. des Manufactures des Glaces & Produits Chimiques de St. Gobain, Chauny & Cirey). U. S. 2,164,418, July 4, 1939 (May 18, 1935).—Means for treating glass surfaces comprise a rotatable support, a vertical

axle carrying the support, and a plurality of spaced resilient blades inclined at an acute angle to the plane of the surface to be treated, each of the blades being connected to the lower portion of the support and spacing members maintaining each blade apart from the other blades, and each of the blades having a rigid, thin, and elongated surface which is substantially parallel to the surface to be treated, the longitudinal direction of the blades being at an acute angle to the direction of the movement of the support.

Means whereby minerals may be melted. D. C. DRILL (American Rock Wool Corp.). U. S. 2,165,242, July 11, 1939 (Jan. 6, 1936).—In apparatus of the character described, a gravity fed blast furnace for melting mineral materials of the type characterized, when melted in the presence of the heated products of combustion, by having a fluxing action upon refractory substances and by being adapted to be shredded into mineral wool, the furnace having a roof portion provided with a material input communicating with the interior of the furnace through the roof portion, a refractory wall portion, a base portion provided with a centrally positioned, hollow metal combination water-cooled molten material outlet and blast fuel input means and being adapted to support a molten pool reservoir of the materials communicating with the combination outlet and input means, the furnace being also provided with a refractory baffle supported and shielded at its periphery with a hollow metal ring communicating with and supported by substantially vertical water pipes passing through the roof portion, the ring and pipes being adapted to be operatively connected to a water-supply system.

Milk bottles. L. J. WEATHERWAX, S. MENEFEE, AND R. B. MENEFEE. Brit. 506,706, June 14, 1939 (Aug. 24, 1938).

Miniature electric lamp. JOHN F. DONOVAN (Canadian General Electric Co., Ltd.). Can. 381,670, May 30, 1939 (March 11, 1936). G.M.H.

Molten glass feeding apparatus. T. F. PEARSON (Crown Cork & Seal Co., Inc.). Can. 381,543, May 23, 1939 (Sept. 8, 1937). G.M.H.

Opal luminescent glasses. GENERAL ELECTRIC CO., LTD. (Patent Treuhand-Ges. für Elektrische Glühlampen). Brit. 507,966, July 5, 1939 (May 13, 1938).

Producing safety glass. OTTO KÄMPFER. Ger. 672,-962, Feb. 23, 1939 (March 14, 1934); IV*c*/39*b*. 27.—Safety glass is produced by the application of thick layers of semisolid artificial resins which are polymerized by oxygen between the glass sheets and by the production of a solid marginal layer between the glass sheets by oxidation. After the union of the glass sheets with the intermediate layer, their exposed faces are subjected to the action of pure oxygen and heat treatment until the end-point is reached which depends on the depth of the solid polymer forming the faces. D.A.B.

Producing sponge glass. RUDOLF HOHLBAUM AND WALTER OTT (Fabian & Co.). Ger. 673,796, March 9, 1939 (Oct. 16, 1937); VI/32*b*. 1.—Molten impure glass of a viscosity corresponding to that of albumin at usual air temperature is stirred throughout by a striking object and is mixed with the furnace atmosphere by a blast of gases or air whose temperature is at least equal to that of the liquid glass; by this means the glass obtains the structure of a sponge. D.A.B.

Quartz-to-metal seal. CORNELIUS BOL AND HENDRICUS J. LEMMENS (Canadian General Electric Co., Ltd.). Can. 382,008, June 13, 1939 (June 24, 1936). G.M.H.

Shatterproof glass production. CAMILLE DREYFUS. Can. 381,229, May 9, 1939 (Aug. 31, 1935; in U. S. Sept. 28, 1934). G.M.H.

Tempering glass. GILT EDGE SAFETY GLASS, LTD., A. W. GROTEFELD, AND J. J. SHAW. Brit. 506,723 and 506,724, June 14, 1939 (Aug. 26, 1937).

Tempering glass sheets. GILT EDGE SAFETY GLASS, LTD., A. W. GROTEFELD, AND J. J. SHAW. Brit. 506,787, June 14, 1939 (Aug. 26, 1937); divided out of 506,723 (see preceding patent).

Winding glass fibers onto a spool. WILHELM KRAUSHAAR (Glasfabrik Wilhelmshütte G.m.b.H.). Ger. 674,334, March 23, 1939 (Dec. 4, 1936); VI/32*a*. 25.—Glass fibers are wound onto a spool in a crosswise overlapping position for further fabrication such as matting. The drum is swung to and fro around the middle point of its longitudinal axis parallel to the direction of the oncoming thread. D.A.B.

Structural Clay Products

Brick, tile, and paving brick. R. LEDUC. *Argile*, No. 186, pp. 7–9; No. 187, pp. 11–15; No. 188, pp. 13–15; No. 189, pp. 13–15 (1938); No. 190, pp. 19–23; No. 191, pp. 19–21; No. 192, pp. 17–19; No. 193, pp. 13–19; No. 194, pp. 9–13 (1939).—Continuing his study of the preparation of clay for brick and tile, L. explains the operation of horizontal propulsive puggers which receive the paste from the wet mixer and the operation of presses. Those presses which maintain pressure for a long time give the best results. In the manufacture of tile from soft, semi-firm, and stiff pastes, the same apparatus is used except that the resistance of stiff pastes requires a different motor power. A résumé is given of the plans of installation of apparatus according to the condition of the clays to be treated. Drying and drying installations and different types of furnaces are discussed, together with the technique of their operation. Engobes and the effect of gypsum, iron oxide, lime, and carbon are noted. See *Ceram. Abs.*, **18** [1] 22 (1939). M.V.C.

Effect of the method of molding on firing. YA. A. SOKOLOV. *Stroitel. Materialy*, **1938**, No. 5, pp. 34–37.—At the temperatures of firing of structural brick the porosity of dry-pressed brick is lower than that of wet-molded brick, but changing the conditions of pressing can change the properties. P.B. & E.S.

Efflorescence on brick of Leningrad works. YA. A. SOKOLOV. *Stroitel. Materialy*, **1938**, No. 7, pp. 34–38.—By investigation of the clays used, S. showed that the soluble salts contained in the clays can not be considered as the principal cause of the efflorescence of sulfate salts. This is chiefly due to flue gases in the artificial drying and firing processes and, to some extent, to fuel ash (in the case of moist green brick and moist flue gases). The addition of lime, schist ash, and calcined pyrites increases efflorescence. Efflorescence is not the chief cause of deterioration of brick in buildings, but it contributes to it; deterioration is chiefly caused by a laminated structure and by insufficient firing of the brick. P.B. & E.S.

Efflorescences causing brick defects. JAROSLAV BÍŠKO. *Zprávy České keram. společnosti*, **15** [1–2] 29–35 (1938).—Brick defects in buildings are often caused by efflorescences formed mostly by magnesium sulfate. The properties of brick taken from stock corresponded to standard specifications and did not show any possibility of dangerous efflorescences. Nevertheless, efflorescences appeared on these brick, when used in masonry, to such an extent that the brick disintegrated. This was caused by soluble salts varying from 0.52% to 18.29%. One specimen brick about 5 kg. in weight contained nearly 1 kg. of soluble salts. On the basis of experiments, B. recommends the testing of a triple quantity of brick in order to ascertain more accurately the quantity of soluble salts present. To prevent the damages caused in brick masonry by soluble salts, it is necessary to (1) ascertain regularly the quantity of soluble salts causing the efflorescence, (2) determine the origin of these salts, and (3) exercise great care in removing them or making them harmless.

New principle in brickwork. ANON. *Jour. Roy. Inst. Brit. Architects*, [3] **46** [14] 725 (1939).—The Rhom brick (devised by W. S. Grice) has an angle of 58°48′ between its parallel sides instead of a right angle. Each pair of brick, when jointed, forms a perfect rhombus, with

a side of 10¼ in., making a wall 9 in. thick. Advantages claimed are better bond, increased speed in laying, and new elevational patterns. Acute angles are fragile but obtuse angles are correspondingly strong. The brick is manufactured under license. R.A.G.

Recent brick pavement developments. GEORGE F. SCHLESINGER. *Roads & Streets*, **82** [1] 51–54 (1939).—S. describes the progress of test strips of highway which have been in use for varying periods of time. Rolling the laid brick before the filler is applied shows some promise in developing better brick roads. Reinforced brick pavements are also being tested in one stretch of road. P.G.H.

Use of a straw extract in brick production. G. I. FAÏNBERG. *Stroitel. Materialy*, **1938**, No. 10–11, pp. 28–31.—The plasticity of clay is increased by the addition of an extract of rye and oats straw. It increases with the increase of concentration of the extract. Plasticity also ncreases with increase of the temperature of the extract when the batch is being mixed. Oats straw gives better results than rye straw, especially when the prepared batch is stored. The mechanical strength of brick is improved by this method. P.B. & E.S.

Weatherproof walls. R. FITZMAURICE. *Brit. Clayworker*, **48** [565] 55–56; [566] 98–101 (1939).—Weatherproof walls must keep out water and wind, and the heat flow through the walls must not be excessive. The designer of such a building must consider locality, design, and occupancy. F. discusses the pros and cons of porous and nonporous structural materials and jointing materials. The effect of pore size on wall leakage is also discussed. R.A.H.

PATENTS

Brick wall construction. A. G. MUNRO. U. S. 2,163,286, June 20, 1939 (March 18, 1938).

Structural brick. HEINRICH MÜLLER. Ger. 673,341, March 2, 1939 (Aug. 21, 1936); V/37*b*. 1.01.—A structural brick is designed with a section removed for the insertion of flat iron holders for use in framework, steelwork, etc. D.A.B.

Refractories

Application of refractories. RUDOLF RASCH. *Wärme*, **60** [51] insert pp. 7–8 (1937).—R. gives an introduction to the Rules of the German Underwriters for Boiler Inspection dealing with refractories. The customer's viewpoint is stressed. The rules number from Ww 37 to Ww 54.

Ww 37: Refractories start with pyrometric cone 26 = 1580°C, and highly refractory materials, with pyrometric cone 36 = 1790°C.

Ww 38: Table of pyrometric cones. *Ibid.*, **61** [3] insert p. 7 (1938).

Ww 39: Classification of firebrick. Class A. *Ibid.*, insert p. 8.

Ww 40: Specifications for high-duty firebrick used for roofs of traveling-grate furnaces. *Ibid.*, [4] insert p. 4.

Ww 41: Specifications for firebrick used for gas generators. *Ibid.*, [5] insert p. 5.

Ww 42: Classification of firebrick. Class B. *Ibid.*, [7] insert p. 9.

Ww 43: Refractory cements. *Ibid.*, [8] insert p. 10.

Ww 44: Silica. *Ibid.*, [12] insert p. 6.

Ww 45: Specifications for silica brick used for coke ovens. *Ibid.*, insert p. 7.

Ww 46: Structure of refractory brick. *Ibid.*, [18] insert p. 7.

Ww 47: Defects caused by the preparation of refractory brick. *Ibid.*, insert p. 8.

Ww 48: Defects caused while shaping, drying, and firing refractory brick. *Ibid.*, insert p. 9.

Ww 49: Mending defects of refractory brick. *Ibid.*, insert p. 10.

Ww 50: Refractory insulating brick. *Ibid.*, [26] insert p. 38. J.M.N.

Bringing insulation facts up to date. G. E. GRIMSHAW. *Ind. Heating*, **6** [1] 61–65, 83; [2] 157–61; [3] 253–60; [4] 343–46 (1939); see *Ceram. Abs.*, **18** [4] 108 (1939). M.H.

Calculations in connection with the use of large brick for blast-furnace linings. G. GROSS. *Stal*, **1937**, No. 9, pp. 1–3.—The use of large brick is advantageous. G. gives a simple method for calculating the conical brickwork for the shaft of a standard blast furnace of 930-cu.m. capacity. B.E.K.

Chemical and mineralogical reactions in silica brick. D. S. BELYANKIN. *Ogneupory*, **6** [11] 1602–1609 (1938).—When silica is fired, the greater part of the quartz present in the raw mix changes into metastable cristobalite, while the remaining part reacts with the admixtures and forms the bond composed of tridymite, silicate glass, and crystalline metasilicates (pseudowollastonite, etc.). During operation in an open-hearth furnace, four zones are developed in the brick: a zone which does not change, a tridymite zone, and a cristobalite zone. In the latter two high-temperature zones, the oxides of iron and manganese are collected, while metasilicate dissociates into orthosilicates and uncombined silica. On the basis of theory it is possible to increase the refractoriness of silica by introducing chromium oxide or by replacing lime by magnesia. Microscopic study is the best means to control the phase composition of silica brick. See *Ceram. Abs.*, **18** [4] 102 (1939). M.V.C.

Clay-magnesite nozzles and stoppers. SHAKHNOVICH. *Ogneupory*, **5** [6] 382 (1937).—Clay-magnesite nozzles and stoppers of improved grade are produced from a mix composed of metallic powders, magnesite brick waste, caustic magnesite, and refractory Chasov-Yar clay. Its composition is 70 to 75% magnesite and 25 to 30% clay. The dry-pressing method in steel molds is used, and the products are fired to 1430° or 1450°. The chemical composition of the nozzles is 20 SiO_2, 11.43 Al_2O_3, 1.33 Fe_2O_3, 4.04 CaO, and 61.63% MgO; loss on ignition, 0.56%. Refractoriness is 1780°, apparent porosity is 40%, and incipient deformation under load occurs at 1450°. M.V.C.

Clays of Poland as a primary source of material for the production of alumina. J. Z. ZALESKI AND K. SARNECKI. *Przemysl Chem.*, **22** [11–12] 548–58 (1938).—Numerous native clays were analyzed. Research covered (1) chemical analyses, (2) weight loss after subjection to incandescent temperatures, (3) effects of temperature on solubility of Al_2O_3 + Fe_2O_3 in HCl, (4) effects of time, temperature, degree of solubility, and concentration of acid on solubility of Al_2O_3 + Fe_2O_3 in H_2SO_4, (5) effect of time on solubility in HCl, (6) effect of concentration and amount of acid on solubility, (7) effect of time and type of acid used on solubility, and (8) effect of time and amount and concentration of acid on solubility in H_2SO_4. D.A.B.

Crystal modifications of zirconia. A clear, fused zirconia produced in the sun furnace. WILLI M. COHN. *Trans. Electrochem. Soc.*, **68**, 65–71 (1935).—In the commercial production of refractory articles made of zirconia, irregularities such as cracking and disintegration were observed. C. investigated the cause of these failures, using the thermal expansion of ZrO_2 under various conditions as a direct means of detecting any changes occurring in the compound. The results obtained were correlated with crystal studies and X-ray patterns. ZrO_2 can be prepared in three distinct modifications (monoclinic, tetragonal, and trigonal) with widely different expansion coefficients. The monoclinic modification is stable between room temperature and 1000°C. On the basis of these observations it was possible to regulate the temperatures in the manufacture of zirconia refractories so as to eliminate cracking and disintegration. Clear, fused zirconia was prepared in the sun furnace at temperatures exceeding 2700°C. This furnace focuses the sun's energy onto a small holder through which a compressed rod of ZrO_2 is slowly passed.

Clear, fused zirconia has a yellowish tint; it is extraordinarily hard and resistant to acids and slags. Illustrated. F.G.H.

Effect of the granulometric composition of grog on the properties of materials with high grog content. E. K. KELER. *Ogneupory*, **5** [9] 623–31 (1937).—Mixes with an optimum relationship between coarse, average, and fine granulations are discussed. The use of grog grain with a maximum size of 1.5 mm. is discussed. M.V.C.

Electrothermic distillation of metals. W. S. LANDIS. *Trans. Electrochem. Soc.*, **72**, 293–316 (1937).—L. describes the production of magnesium by the reduction of dead-burned magnesite in a closed electric-arc furnace, using anthracite coal or low-ash coke. Illustrated. F.G.H.

Furnace roofs and thermal losses. FRANCIS R. PYNE. *Eng. Mining Jour.*, **140** [5] 47–48 (1939).—P. discusses the desirability of thermal insulation on the roofs of metallurgical furnaces. Heat losses through clay, silica, magnesite, and vermiculite are discussed. Five tables. J.L.G.

Magnesite brick with a forsterite bond. A. G. MARANTS. *Ogneupory*, **6** [10] 1507–18 (1938).—The use of dead-burned magnesite containing at least 90% MgO is necessary for the production of high-grade brick with a forsterite bond. Talc carbonate rock, dunite, or serpentine rock may also be used. The methods of manufacture are similar to those used for ordinary magnesite brick. The composition of the mix with a forsterite binding is 85 fired magnesite, 14.7 talc, and 0.3 to 0.5% clay. The firing temperature is 1540° to 1560°. The introduction of talc considerably increases deformation under load at high temperature. High-grade brick begin to soften at 1600° to 1620°. M.V.C.

Magnesite refractories. FELIX SINGER. *Brit. Clayworker*, **48** [566] 88–92 (1939).—A general discussion of the properties and manufacture of magnesite brick is presented. R.A.H.

Manufacture of plain carbon steels in top-charge rapid type furnace. W. B. WALLIS. *Trans. Electrochem. Soc.*, **68**, 43–51 (1935).—The advantages of the top-charge type of electric steel furnace are discussed. Compared with the older type of furnace, which was charged through a door, there is a substantial saving in power, electrodes, refractories, and labor, due largely to the more rapid charging and shorter periods between two successive chargings of the top-charge type. The furnace roof is swung to one side during charging. Basic refractories are used in both the bowl and the roof. A luting of powdered chrome ore is used as a seal between the roof and the bowl of the furnace. Illustrated. F.G.H.

Physics of heat insulation. ALPHEUS W. SMITH. *Ceram. Age*, **33** [2] 42–44, 47 (1939); *Brit. Clayworker*, **48** [564] 23–25 (1939).—A. reviews and discusses studies of heat transfer in porous and fibrous bodies, conduction of heat in powders and granular materials, and heat transfer through walls. **Discussion.** H. W. RUSSELL. *Ceram. Age*, **33** [2] 47 (1939). F.G.H. + R.A.H.

Possibility of increasing the mechanical strength of raw brick by means of sulfite waste liquor. V. M. STRELETS AND V. V. RADIN. *Ogneupory*, **5** [9] 657 (1937).—The addition of sulfite waste liquor causes an increase in the mechanical strength of raw dry brick up to a certain limit, after which the mechanical strength of the products diminishes with increased addition of the liquor. The maximum addition is 4 to 5%. M.V.C.

Pot-manufacturing plants. ZSCH. *Glashütte*, **69** [5] 73–75 (1939).—A good refractory clay, proper preparation in clean well-arranged rooms, and a high firing temperature are essential to good pot manufacture. Defective or worn pots cause streaks, stones, and other defects in glass. Suggestions are given for the improved manufacture and care of pots. M.V.C.

Producing slag structural brick and investigating its properties. I. L. ZNACHKO-YAVORSKIĬ. *Stroitel. Materialy*, **1938**, No. 4, pp. 48–53. P.B. & E.S.

Production and service of unfired grogless refractories from Dsekh rock. F. I. MELNIKOV. *Ogneupory*, **6** [10] 1540–42 (1938).—Experiments show that it is possible to manufacture unfired grogless refractories with a sulfite waste liquor binding by means of the semidry method. These refractories may be used for lining kilns and furnaces for firing ceramic products. M.V.C.

Production of special magnesite refractories. A. BEREZHNOĬ. *Stal*, **1938**, No. 1, pp. 30–37.—B. attempts to show the influence of composition of the charge and method of preparation on the quality and properties of magnesite refractories. The use of sintered magnesite improves the structure of periclase and raises the heat stability of magnesite refractories. The addition of caustic magnesite to the charge improves the quality of the brick. The addition of alumina to the charge increases the heat stability of magnesite brick. In firing at a sufficiently high temperature, spinel is formed, which is the binding material in these brick, and it is possible to bring the beginning of deformation under load to 1700°C. Spinel is recommended as a binding material in the preparation of chrome-magnesite brick, which are cheaper and often possess higher properties than magnesite brick. The use of quartzite, talc, dunite, etc., makes possible the use of forsterite binding in magnesite refractories. These refractories possess a high temperature of beginning of deformation under load and a high stability against the action of aggressive basic slags of the open-hearth furnace. The production process and the properties of special magnesite brick are presented. B.E.K.

Production of steel-casting refractories at the Krasnyi Oktyabr Works. P. N. GOROVENKO. *Ogneupory*, **6** [11] 1588–93 (1938).—G. gives a series of suggestions for lowering the great waste in the production of steel-casting refractories. M.V.C.

Progress in furnace design. D. W. RUDORFF. *Eng. & Boiler House Rev.*, **52** [10] 666 (1939).—R. reviews the types of boiler furnace wall construction such as solid-refractory, air-cooled, and water-tube walls with either bare water tubes or tubes covered with cast iron or refractory-faced blocks. The effect of slag on the refractories is the most serious problem; it depends upon the velocity of flow, thickness of slag, solubility of the refractories in the slag at a given temperature, and the amount of slag produced by the prevailing conditions. The flow of slag is little affected by the slope of the walls; a change in the inclination from 30° to 90° should theoretically produce an increase in velocity of 26% and a decrease of 20% in the thickness of the film. High-iron slags are the most corrosive, and high-alumina brick showed the greatest resistance to slag attack. B.C.R.

Properties of carbon at the arc temperature. N. K. CHANEY, V. C. HAMISTER, AND S. W. GLASS. *Trans. Electrochem. Soc.*, **67**, 107–50 (1935).—The entire field bearing on the properties of carbon at arc temperatures is reviewed, and new experimental data are submitted. Results indicate that (1) carbon sublimes without melting at ordinary atmospheric pressure, (2) the temperature of the positive crater approaches a limiting constant value, (3) the maximum brightness temperature of the carbon crater is 3810°K, (4) the wave length of maximum radiation intensity lies between 0.735 and 0.740 μ, and (5) the probable true crater temperature lies between 3925° and 3970°K. The preferred conditions for ensuring maximum crater brightness are established. Illustrated. F.G.H.

Reasons for the premature wear of the upper part of the shaft of blast furnaces. N. KRATENKO. *Stal*, **1937**, No. 9, pp. 4–9.—K. discusses reasons for the deterioration of the upper part of the shafts of blast furnaces of a Russian metallurgical works. Wear appears to have been due partly to incorrect construction and partly to the nature of the ore used in the furnaces. B.E.K.

Refractories from quartz glass for open-hearth furnaces. I. L. MOVSHEVICH. *Ogneupory*, **6** [10] 1555 (1938).—The refractoriness of cones cut out from quartz-glass brick is 1750° to 1770°, and deformation under load begins at 1660°. Quartz-glass brick were used in the crown of an open-hearth furnace which was operated for 68 days with 116 melts. One half of the brick changed into cristobalite and represented a dense monolithic mass of milk-white color. Slag did not penetrate into the brick, whose

surface was covered with a thin brown layer 0.5 mm. thick. The transformation of quartz glass into cristobalite occurred without destruction of the brick structure. M.V.C.

Refractories used in the steel foundry. A. V. LEUN. *Ind. Heating*, **6** [6] 543–48 (1939).—The choice of a brick is governed by the kind of slag it must come in contact with. In the different types of furnaces used in steel foundries, refractories of acid character are silica, fire clay, high alumina special refractory brick, sillimanite, silicon carbide, and insulating refractory brick, and those of basic character are chrome and magnesite brick. The use of these types in the parts of open-hearth, electric, and stress-relieving furnaces, in ladles, and in regenerators is described briefly. M.H.

Refractory brick for coke ovens. R. RASCH. *Chem.-Ztg.*, **63** [27] 233–37 (1939).—The evaluation of silica brick for use in coke-oven beds shows that brick produced in Germany is good and uniform. Technical tests show that, in addition to fabrication flaws, numerous factors can have a definite influence on the brick. Results of tests on silica brick for coke-oven use showed that brick of similar characteristics but produced by different manufacturers were of good conformity. The determination of the quality of chamotte brick for coke-oven work is still in progress. R. discusses the use of chamotte brick and gives an analysis of silica brick and general characteristics of brick to be used for coke-oven purposes. D.A.B.

Refractory lining of water-gas generators. M. NAZAROV. *Ogneupory*, **6** [10] 1543–47 (1938).—Service conditions of refractory linings of water-gas generators are similar to those of linings of the upper part of blast furnaces. Refractories must possess (1) an increased resistance to wear, (2) sufficient gas permeability, (3) sufficient thermal resistance, (4) increased mechanical strength, and (5) low porosity. M.V.C.

Refractory linings for combustion chambers on ships. YVES LETORT. *Rev. Combustibles Liquides*, **17** [161] 1–8 (1939); *Chem. Abs.*, **33**, 4392 (1939).—Refractoriness is not a prime consideration because of corrosive qualities of fuel gases which contain Na_2SO_4 and sometimes even suspended Fe. The gas temperature is about 1200°, at which Na_2SO_4 becomes a boiling liquid, dissociates, and penetrates brick pores, attacking free SiO_2 and free Al_2O_3. The size of pores and percentage of combined silicates, which are not attacked, therefore, are the determining factors, eliminating refractories other than the clays and the crystalline Al monosilicates, andalusite, disthene or kyanite, and sillimanite. Sillimanite is the best of all these but is not obtainable in large amounts.

Service of Dinas brick in the arch of a reverberatory copper-smelting furnace. B. V. IVANOV. *Tsvetnye Metally*, **1938**, No. 9, pp. 95–97.—Dinas brick which was removed from the furnace wall after only $2^1/_2$ months' service showed a decrease in length from an original 475 mm. to 115 to 155 mm. The brick showed three zones: (1) unchanged, (2) intermediate, and (3) tridymite. The lumps of quartzite retained their original appearance in all except the third zone. The cement of the brick was altered. The intermediate zone was abundant in $CaSiO_3$, while the third zone was rich in Fe_2O_3, FeO, Cu_2O, and ZnO. The rapid wear of the brick was due not to the high temperature of the furnace but to the dust of the basic charge and the harmful influence of the ferruginous liquid fayalite slags. The basic dust and the slag spatter form low-melting eutectics with the cementing mass of the brick which gradually flows out and uncovers the large lumps of quartzite. To prolong the service of the Dinas walls it is suggested that the first sections of the arch should be lined with high-grade Dinas brick prepared from the best quartzites and containing the least amount of lime as a binder. It is proposed to try Dinas brick with a siliceous binder. B.Z.K.

Service of refractory lining in electric aluminum-melting furnaces. I. I. KUZMENKO. *Ogneupory*, **6** [11] 1625–31 (1938).—During melting, aluminum oxidizes and reduces SiO_2, Fe_2O_3, and TiO_2 present in the grog lining of the tank. When melted, aluminum penetrates easily into the brick, especially into the joints. The most suitable refractory is coarse-grained grog (10 mm. grain size and 90% grog). A high alumina content and a low content in free silica and iron are necessary. Crown brick must possess a high thermal resistance, mechanical strength, and electro-insulating properties. See *Ceram. Abs.*, **18** [3] 77; [5] 130 (1939). M.V.C.

Silica brick resistant to spalling for hot repair. A. V. DEMAKOVA. *Ogneupory*, **6** [11] 1594–601 (1938).—The introduction of various admixtures (clay) into the mix does not improve the thermal resistance of silica brick. The lowest thermal resistance was found in brick with a tridymite structure (in the presence of cristobalite) and low specific gravity. High thermal resistance was shown by ordinary silica brick with a high specific gravity (2.54 to 2.58) fired at 1280°. Such brick resist sharp temperature fluctuations well. With decreasing specific gravity and increasing tridymite content, the thermal resistance of silica brick decreases. M.V.C.

Silicon carbide generator linings. JAMES PENNEY. *Amer. Gas Jour.*, **150** [6] 52 (1939).—For lining carburetted water-gas sets using coke having an ash-fusion temperature of 2700° to 2800°F, linings of silicon carbide are considered to be more economical and satisfactory than those of fire-clay brick, although the latter gave satisfactory service when fuels having a low ash-fusion temperature were used. The silicon carbide lining installation cost $1390 and gave 8000 hr. of service without repairs; the fire-clay brick installation cost $285 and gave 1800 hr. of service. In addition, better operating conditions resulted with the use of silicon carbide linings because less clinker adhered to the brickwork and its removal was easier. A detailed drawing shows the construction of the lining. B.C.R.

Stabilization of dolomite calcined at high temperatures and the problem of dolomite refractories. D. A. NIRENSHTEĬN. *Ogneupory*, **6** [10] 1494–1507; [11] 1572–87 (1938).—N. studied the properties of dead-burned magnesite with regard to hydration and crumbling and the production of a basic highly refractory product. Diagrams of the composition and properties of fired dolomite with a variable content in alumina, silica, and Fe_2O_3 are given. Dolomite containing any one of these components is not satisfactory with regard to refractoriness, hardness, and uniform resistance to moisture. Silica is a component whose basic function is to change calcium oxide into tricalcium silicate; because of an incomplete reaction at high temperatures, however, dicalcium silicate is formed which is unstable. Dolomite refractories containing silica only have a low resistance to pressure. Alumina is more effective than Fe_2O_3. See "Dolomite—," *Ceram. Abs.*, **18** [2] 51 (1939). M.V.C.

Steel-ladle refractories. A. JACKSON. *Metallurgia*, **13**, 93–94 (1936).—Types of refractory materials used and the designs employed are briefly discussed. F.G.H.

Superrefractories. FRANK J. TONE. *Trans. Electrochem. Soc.*, **68**, 22–26 (1935).—T. discusses trends in the development and applications of superrefractories. F.G.H.

Technological production of refractory floating mold tops. L. ZILBERFARB. *Stal*, **1938**, No. 3, pp. 21–24.—Refractory floating mold tops are used to prolong the time during which the steel remains liquid. They should (1) possess a high mechanical toughness, (2) be sufficiently refractory, (3) have sufficient thermal stability and a high stability against the action of molten steel, and (4) be produced in regular sizes and design at a low price. Their production is described. To obtain mold tops of high quality, light sintered refractory clay should be added to the charge. The tops should be fired at 1050° to 1100°C. B.E.K.

Thermal stability of firebrick: I. B. YA. PINES. *Zhur. Tekh. Fiz.*, **8** [24] 2126–49 (1938).—The theories of Norton and of Winkelmann and Schott regarding the thermal stability of refractories are discussed in detail. P. claims that the formulas are not applicable in all cases because they do not take into account the heterogeneity and the plasticity of refractories. In the case of a brittle

uniform brick subjected to rapid heating or cooling, the thermal stability may be found from the equation $R = P/Eak\Delta T$, where k is a function of xl/λ (l = the linear dimension of the refractory in the direction of temperature changes, x = coefficient of heat loss from the refractory to the medium in which it is placed, and λ = the coefficient of heat transfer of the refractory). Formulas which take into account the heterogeneity and the plasticity are given. B.Z.K.

Use of refractories in the glass industry. W. J. Rees. *Refrac. Jour.*, **15** [4] 153 (1939).—Although, in the manufacture of glass pots, aluminous clays are more resistant to the corrosive action of glass, siliceous clays are usually preferred because of their greater mechanical strength at high temperatures. Furthermore, aluminous clays tend to produce strings and cords in the glass, as they are less soluble in the melt than siliceous clays. Pugging in conjunction with deairing is becoming increasingly prevalent. Both hand-molding and slip-casting processes are used in the manufacture of pots. The pots are usually given a preliminary firing at 1000°C in a pot arch furnace before being vitrified in the glassmelting furnace. Tank furnaces varying in capacity up to 2000 tons of glass are often operated at 1500° to 1600°C, thus requiring a careful selection of refractories. Sillimanite tank blocks fired at 1500°C or higher and having a porosity of less than 18% are superior to many other materials. Sillimanite blocks may be made either by slip casting or by tamping with pneumatic hammers. Cast mullite blocks made by fusing mixtures of ball clay and bauxite in an electric arc and casting in oil-sand molds have proved highly successful, but their cost (£40 a ton) makes them less economical than good sillimanite blocks. B.C.R.

Utilization of dust-like quartz (marshalite) in the refractory industry. I. L. Movshevich. *Ogneupory*, **6** [10] 1527–533 (1938).—The low content of SiO_2 (91%) and the large amount of alumina and alkalis in dust-like quartz lower its refractoriness, while its high dispersion affects the thermal stability of silica products. Tests show, however, that it may be used successfully as a binding agent for silica products. M.V.C.

Zircon refractories. W. R. Poole. *Chem. Eng. & Mining Rev.*, **31** [366] 250 (1939).—Zircon is separated by flotation from the other minerals present in the black-sand concentrate occurring on the beaches of New South Wales. Refractories made from this zircon possess refractoriness over 1800°C, deformation under load of 25 lb./sq. in. starting at 1420°C and amounting to 20% at 1500°C, and a true porosity of 29%. Brick were made with various types of bonding material, such as lime, magnesia, rutile, and phosphoric acid. Experiments are in progress to produce a refractory by the addition of either Al_2O_3 or MgO to zircon to form mullite or forsterite, respectively, according to the following formulas: (1) $2ZrO_2 \cdot SiO_2 + 3Al_2O_3 = 2ZrO_2 + 3Al_2O_3 \cdot 2SiO_2$, and (2) $ZrO_2 \cdot SiO_2 + 2MgO = ZrO_2 + 2MgO \cdot SiO_2$. Detailed methods for the chemical analysis of the beach-sand concentrate are given. B.C.R.

PATENTS

Brick grating work for heat regenerators, blast heaters, heat accumulators, etc. Rhenania Fabrik feuerfester Produkte G.m.b.H. Ger. 672,106, Feb. 2, 1939 (Oct. 29, 1929); V/24*c*. 5.01.—Brick grating work for heat regenerators, blast heaters, and heat accumulators is provided with border brickwork decreasing in thickness from the heated zones to the cooler zones. The grating work with reduced thickness has such increased dimensions that the heat conductivity for equal brick weight is about the same throughout the entire grating work. D.A.B.

Impregnation of bauxite. Blakeslee Barnes (Chemical Construction Corp.). U. S. 2,165,173, July 4, 1939 (Sept. 22, 1937).—A method of producing bauxite impregnated with coke comprises heating bauxite to temperatures substantially in excess of those necessary for the decomposition of acid sludge, intimately admixing the hot bauxite with acid sludge whereby sulfur dioxide is evolved and coke is formed, and withdrawing the mixture of bauxite and coke.

Production of refractory material. R. C. Benner and J. C. McMullen (Carborundum Co.). U. S. 2,164,635, July 4, 1939 (Dec. 30, 1935).—The method of making a refractory article comprises molding molten refractory material into an intermediate article comprising a solidified outer shell having a casting hole, a re-entrant portion extending about the shell, and a molten center portion, causing deposition of solid material from the molten center portion on the inner wall of the shell to build it up to the desired shape, removing excess molten material from the shell, and dividing the shell along the re-entrant portion to remove the portion of the shell including the casting hole and produce a hollow refractory article having an opening of substantial area.

Refractory material for use in basic-process metallurgical furnaces. G. B. Crespi. Brit. 507,715, July 5, 1939 (Aug. 27, 1937).

Terra Cotta

Ceramic and glass face tile, especially façade face tile, and their joining with the underlayer. Otakar Kallauner. *Zprávy České keram. společnosti*, **15** [1–2] 10–12 (1938).—K. discusses the classification of ceramic and glass face tile and ways of joining them with the underlayer. The problem of the careful joining of the face tile with the underlayer has been examined intensively in recent years but is not yet solved. Tests show that glass tile do not resist alternating sudden changes of temperature as well as ceramic face tile.

Ceramics in Golden Gate buildings. Anon. *Bull. Amer. Ceram. Soc.*, **18** [7] 271, 272 (1939); see *ibid.*, [2] 62.

Leadless low-fusing glaze for facing materials. L. M. Blyumen. *Stroitel. Materialy*, **1938,** No. 10–11, pp. 37–40.—A glaze without lead and boron is not suitable for facing tile, as it is not quite stable against crazing. A white-colored glaze (enamel) does not have sufficient opacity. Crazing can be eliminated by adding a small amount of boron-containing ore (inderite). Better results can be obtained with glazes containing a small amount of calcine (containing 8 to 12% lead and tin). P.B. & E.S.

Modra stove tile of the 15th century. Heřman Landsfeld. *Zprávy České keram. společnosti*, **15** [1–2] 54–56 (1938).—The Potter's Guild Order of Modra shows that stove tile were produced in 1636, but tile dating from 1628 have also been found. The findings show a high artistic level and technical perfection. Stoves and pots were produced in Modra in the 16th century and possibly earlier.

Preparation of small and large tubes of ceramic materials. P. Franke. *Keram. Rundschau*, **46** [41] 485–86 (1938).—The manufacture of seamless and two-seam tubes is described. The usual methods are pressing and slip casting with and without a core. F.E.V.

PATENTS

Firebox for Dutch tile oven. Rudolf Uhlig. Ger. 673,339, March 2, 1939 (Dec. 21, 1937); V/36*a*. 15.01.—The construction of a firebox for Dutch tile ovens consisting of fireproof ceramic materials is described in detail. D.A.B.

Hollow roofing tile. Paula Mayer Sperle. Ger. 667,504, Oct. 20, 1938 (Dec. 1, 1932). Ger. 673,342, March 2, 1939 (Nov. 23, 1935); V/37*b*. 1.01.—A hollow roofing tile is made from sintered clay. D.A.B.

Tile-texturing apparatus. Henry D. Holland (Cooksville Co., Ltd.). Can. 381,542, May 23, 1939 (April 20, 1938).—Apparatus for texturing extruded hollow building

tile comprises a frame located between the extrusion die and the cutting table and supporting a movable brush and means for moving the brush so that its bristles are repeatedly pressed into penetrating engagement with the adjacent side of the tile column as the latter moves past and link connections between the brush and frame which serve to keep the brush at all times parallel with the side of the tile column. G.M.H.

Whiteware

Calcareous earthenware. J. LIEBSCHER. *Zprávy České keram. společnosti*, **15** [1–2] 24–27 (1938).—Calcareous earthenware is fired at 1080° to 1150°C, which is considerably lower than the firing temperature of argillaceous earthenware. To produce pure white earthenware it is necessary to use only raw materials which remain white on firing. Rich deposits of appropriate raw materials occur in the environs of Měcholupy, Vildštejn, Piešťany, and Lučenec. The individual components for producing calcareous earthenware must be ground fine in drum mills. The composition is approximately kaolinite 45 to 55, quartz 30 to 35, and calcium carbonate 25 to 10 parts. Earthenware consisting of 60 Měcholupy loam, 30 Flehava loam, 36 ground quartz, 27 washed chalk, and 6 parts of kaolin with a small addition of cobalt carbonate, fired at 1040°C, has good properties; glazes adhere well to the surface. The unfired objects may be decorated with colors. Good colored glazes and dull flowing glazes were obtained in one firing.

Defeating the drip. ANON. *World Digest*, **1** [3] 46 (1939).—Teapot and jug spouts can be prevented from dripping by a device which consists of a tiny capillary groove cut into the inner surface of the lip. When pouring ceases, the drip, which normally runs down the outside of the spout, slips back along the groove, leaving no trace of moisture on the lip. A.B.S.

Devitrification of glazes. A. M. BLUMEN. *Stroitel. Materialy*, **1938,** No. 12, pp. 14–16.—Water vapor, especially in the presence of NaCl, acts as a mineralizer and contributes to the devitrification of glazes. P.B. & E.S.

Dry method of preparing fine ceramic masses. G. N. FILINTZEV. *Stroitel. Materialy*, **1938,** No. 8–9, pp. 40–45.—Slurry for casting porcelain and faience masses which is prepared from dry finely ground materials does not differ from the so-called "nonpressing" slurry. The materials must be finely ground and subjected to air separation. Masses screened on a 400-mesh/cm.^{2} sieve can be pressed satisfactorily; suitable strength was obtained by plastic clay and gluey additions. The method is recommended for stamped porcelain ware, floor and wall tile, etc. After storage and vacuum treatment, plastic masses prepared by the dry method gave results similar to those of masses prepared by the wet method, but a less white ware was obtained. P.B. & E.S.

Evolution of an English home. ANON. *Pottery & Glass Record*, **21** [5] 121–22 (1939).—Domestic pottery is being increasingly used in English homes. A brief review is given of the kinds of pottery used in the past and of the efforts made by modern potters to keep abreast of development. A.B.S.

Increase in strength of unfired ware and the one-course firing of porcelain ware. G. K. TERESCHENKO. *Stroitel. Materialy*, **1938,** No. 8–9, pp. 50–53.—The strength of dry porcelain ware can be increased by organic additions. Potato starch added in an amount of 1.5% increases the strength of the ware, is distributed equally throughout the mass, and leads to a high resistance to deterioration by water. Dry ware can be well glazed. Sulfite cellulose, dextrin, and molasses increase the bending strength of dry ware but are distributed unequally throughout the mass, resulting in an increase of compactness at different places which leads to difficulties when glazing. T. concludes that the problem of one-course firing of porcelain can be solved. P.B. & E.S.

Lead-stable glazes and their testing. H. HARKORT. *Keram. Rundschau*, **46** [41] 481–84 (1938).—The maximum permissible amount of lead in blood is 0.06 mg./100 cc. Methods of determining lead solubility are given. Different methods do not give comparable results. Alumina increases the stability of lead silicates. Boron is advocated for faience glazes. In somes cases, two frits are necessary. Artistic glazes often show high solubility. F.E.V.

Passage of an electric current through porcelain at high temperatures. K. SCHAUDINN. *Ver. Deut. Elektrotech. Fachber.*, **10,** 139–42 (1938); abstracted in *Physik. Ber.*, **20** [8] 861 (1939).—Experiments show that the resistance-temperature curve differs from the usual shape. This behavior between 200° and 600°C must be caused by electrolytic polarization, to which the electrode material contributes. The polarization current can not be suppressed by alternating current. Such polarization phenomena must be taken into account when making resistance measurements. Other ceramic materials did not show polarization; it is assumed, therefore, that this phenomenon occurs only in materials rich in feldspar. M.H.

Use of dustlike quartz in the porcelain and faience industry. G. K. TERESCHENKO. *Stroitel. Materialy*, **1938,** No. 8–9, pp. 34–39.—Previously concentrated marshalite can be used in faience masses. Plastifiers or vacuum treating must be used to increase the solidity of the masses. Very white masses are obtained only with a low content of plastic clay. For porcelain, marshalite should be carefully concentrated on a screen of 1600 to 2500 mesh/cm.^{2}. T. gives compositions of masses and of glazes to be used with them. P.B. & E.S.

Whitening porcelain by cobalt compounds. A. S. BERKMAN. *Stroitel. Materialy*, **1938,** No. 12, pp. 16–20.—The introduction of Co compounds into a porcelain glaze improves the color and appearance of the ware. The compounds can be added in the form of soluble salts and in small quantities varying with the local production conditions. P.B. & E.S.

PATENTS

Defecator. W. C. GROENIGER (John B. Pierce Foundation). U. S. 2,164,321, July 4, 1939 (July 9, 1938).

Manufacture of pottery ware. J. & G. MEAKIN, LTD., AND J. F. MEAKIN. Brit. 507,360, June 28, 1939 (March 28, 1938).

Spark plug. ENRICO ZANZI. Can. 381,253, May 9, 1939 (Nov. 17, 1937). G.M.H.

Water closet. SVEN DUNER (Duner Co.). U. S. 2,165,243, July 11, 1939 (Dec. 18, 1936).

Water closet or defecator. W. C. GROENIGER (John B. Pierce Foundation). U. S. 2,164,319, July 4, 1939 (Dec. 31, 1937).

Water-closet suites. ASSOCIATED CLAY INDUSTRIES, LTD., AND A. F. BUTTLE. Brit. 507,908, July 5, 1939 (Dec. 18, 1937).

Equipment and Apparatus

Aeroform drier. A. O. HURXTHAL. *Ind. Eng. Chem.*, **30** [9] 1004–1006 (1938).—The material coming from a filter or from any mechanical dewatering device is wholly unsuited for quick drying. Even when separated into small forms advantageous for drying, many filtered materials, after being formed and then removed to any kind of a conveyer, will immediately settle back into a solid mass formation and defeat the purpose of the special forming. The application of heat to the preforming mechanism (to evaporate sufficient water so that the formed

material will hold its shape) eliminates this difficulty. The predried forms can then be removed for drying on a continuously moving screen conveyer through which heated air is recirculated to finish the drying operation. The aeroform drier employs this two-stage drying operation. The forming and predrying are accomplished on a steam-heated surface drum drier having special forming cavities. The final drying is done on a horizontal continuous screen-conveyer drier. The aeroform drier is particularly adapted to the drying of clays and other materials from which the initial water has been mechanically removed. Illustrated. F.G.H.

Chelate compounds as flotation reagents: I. C. C. DeWitt and Frederick von Batchelder. *Jour. Amer. Chem. Soc.*, **61** [5] 1247–49 (1939).—The data presented show that salicylaldoxime is an effective flotation reagent for the separation of chalcocite, covellite, azurite, malachite, and cuprite from siliceous gangue materials. Illustrated. F.G.H.

Concentric-cylinder motor-driven viscometer. Richard H. Wilhelm and Donald M. Wroughton. *Ind. Eng. Chem.*, **31** [4] 482–86 (1939).—The design of a motor-driven concentric-cylinder viscometer is presented. The essential features of the instrument are (1) continuous operation at a series of speeds, (2) dynamometer mount of the motor, which eliminates friction to a large degree, and (3) accurate speed measurement by means of a simple stroboscopic device. The viscometer was calibrated in both the viscous and turbulent ranges by means of glycerol-water solutions. This calibration is presented as a specific friction factor *vs.* Reynolds number plot. The necessity of providing baffles on the wall of the outer stationary cylinder for stable operation, as well as the influence of these baffles on the shape of the calibration curve, is pointed out. The instrument was developed to measure properties of certain suspensions, but it is also useful for measuring the viscosities of liquids. Illustrated. F.G.H.

Deairing in pottery manufacture. Anon. *Ceram. Ind.*, **27** [5] 334–36 (1936).—A survey among potteries using the deairing process shows the greatest advantage to be an improvement in the product; it is almost invariably stronger and denser and has less absorption. There is some disagreement as to the proper amount of vacuum. In nearly every case the workability has been improved, but two pieces of deaired clay will not join together as well as those not deaired. E.J.V.

Determination of adhesion energy and the problem of a characteristic value for collectors. Contribution to flotation. S. Valentiner. *Kolloid-Z.*, **83**, 1–9 (April, 1938); *Metals & Alloys*, **10** [1] MA 14 (1939).—The following factors must be considered in evaluating the suitability of a collector for flotation: (1) adsorption of the collector molecules by the components of the mixture and (2) interaction between the molecules of the collector and frother. Contact-angle determination or, better, adhesion-energy determinations yield information on the adsorption capacity of the components. When interpreting the experimental data, the solubility conditions must be considered. Adhesion determinations were made for a number of systems. The surface tension of several solutions, their boundary tension against pure benzol and water, and the contact angles of some solutions against galena were determined.

Developments in grinding. Lincoln T. Work. *Ind. Eng. Chem.*, **30** [2] 130–35 (1938).—W. reviews recent developments in crushing and pulverizing mill construction and describes the more distinctive new mills. The normal improvements of the standard mill types consist of the utilization of newer materials of construction and of varying combinations of drives, feeders, mills, classifiers, and collectors. Problems of reducing energy consumption by the more effective use of grinding forces, of lowering maintenance charges by minimizing wear on costly parts, and of classifying the materials to obtain the desired size reduction well into subsieve sizes by control in design and operation continue as dominant factors in the development of new types of mills. Adjuncts to the milling process include preconditioning of the material for grindability, the use of addition agents to avoid mill packing and to give desired qualities to the product, and the use of flotation in connection with the grinding and classification of nonmetallic ores. Illustrated. F.G.H.

Drum drying. D. J. Van Marle. *Ind. Eng. Chem.*, **30** [9] 1006–1008 (1938).—In drum drying, the material, usually in fluid form with solids either in solution or suspension, is dried on the surface of an internally heated revolving drum. Forms of drum driers and their applications are discussed from the standpoints of (1) nature of the product to be dried, (2) the drum drier as an instrument of heat transfer, (3) design and construction of the drier, (4) adaptation of the drier to the product, (5) conditions under which the drier operates, and (6) economies to be effected within the drum drier as well as in connection with the process in which it is used. Illustrated. F.G.H.

Drying clay in drum driers. B. N. Gak. *Ogneupory*, **3** [12] 913–23 (1935).—G. studied the causes of the low efficiency of drum driers. The influence of the fineness of clay and its humidity is discussed. M.V.C.

Electric drying of ceramic products. G. L. Efremov. *Ogneupory*, **4** [1] 33–36 (1936).—The addition of 0.3% sodium chloride to the mix accelerates the rate of drying and diminishes the formation of defects such as cracks, flaws, and deformation of the product. M.V.C.

Electric drying of glassmelting pots. M. A. Vaĭnberg. *Stekolnaya Prom.*, **14** [11] 6–8 (1938).—Methods used to dry glassmelting pots by means of alternating current are discussed. M.V.C.

Electrical resistance alloys; nickel chromium as heating-element material. Fred P. Peters. *Trans. Electrochem. Soc.*, **68**, 29–42 (1935); see "Ni-Cr—," *Ceram. Abs.*, **17** [1] 29 (1938). F.G.H.

Electrical signalization for the Amsler press. R. N. Katznelson and M. A. Finkelsteĭn. *Stroitel. Materialy*, **1938**, No. 10–11, pp. 42–43.—A device for signaling the moment when the screw is completely lowered or completely elevated, so that the switch may be turned off, has been constructed. P.B. & E.S.

Evaporation rates of moisture from a wet material and from a free water surface. A. E. Stacey, Jr. *Ind. Eng. Chem.*, **30** [12] 1385–89 (1938).—Factors which affect the time of drying of clay are discussed. Illustrated. See *Ceram. Abs.*, **18** [2] 55 (1939). F.G.H.

Filter drying. D. F. Irvin. *Ind. Eng. Chem.*, **30** [9] 1002–1003 (1938).—Fundamental principles of operation are discussed briefly. Illustrated. F.G.H.

Flow of suspensions through pipes. Richard H. Wilhelm, Donald M. Wroughton, and Willis F. Loeffel. *Ind. Eng. Chem.*, **31** [5] 622–29 (1939).—Suspensions of cement rock and of Filter-Cel in water were pumped through 0.75-, 1.5-, and 3-in. pipes at measured velocities. Pressure drop data for 27-ft. lengths of pipe are presented. The apparent viscosity characteristics of all suspensions, which were determined in a rotating viscometer, are included. The cement-rock concentrations were 54 and 62% by weight; those of Filter-Cel varied from 21 to 34%. Velocities ranged from 0.3 to 14 ft./sec., and pressure drops, from 30 to 7200 lb./sq.ft. (calculated per 100 ft. of pipe). Cement-rock suspensions were found to flow in two regimes which were treated as "plug" and turbulent flow. A separate correlation, involving pipe and viscometer data, is presented for each type of flow. The variables, friction factor and Reynolds number, are used for turbulent flow, and friction factor and velocity, for "plug" flow. The apparent viscosity of Filter-Cel suspensions increases somewhat with rate of shear. By using viscosity at zero shear, all pumpable suspensions correlate on a friction-factor *vs.* Reynolds-number plot. Viscous and turbulent flow are evident for this suspension, but no "plug" flow. Illustrated. F.G.H.

Lubrication in heat-using industries. B. H. Porter. *Ind. Heating*, **6** [6] 491–94 (1939).—P. describes the advantages of colloidal graphite as a suspension in water, etc., for lubrication at high temperatures; it resists oxidation at high temperatures, has no abrasive impurities, remains at the point of application, and retains its unctuous

qualities under extreme conditions of heat and pressure. Methods of application are described in detail. The graphite film should be allowed to dry on the part before being put into service. Colloidal graphite in castor or mineral oil is an excellent mold lubricant for automatic typesetting machines and kiln and annealing-furnace cars. Six references. See "Application of colloidal graphite—," *Ceram. Abs.*, **18** [1] 14 (1939). M.H.

Mapping temperatures by pyrometric paints. W. E. D. *Discovery*, [N.S.] **2** [13] 185–86 (1939).—The double salt of cupric and mercuric iodide is scarlet below 60°C, brown between 65° and 75°C, and black at 110°C. The salt is mixed with oil varnish or lacquer. "Patent bronzes" are composed of aluminum powder, tannin, and oxalic acid and are tinted with heat-sensitive aniline dyes. The Thermocolors of the I. G. Farbenindustrie A.-G. have more definite color changes. A.B.S.

Metallic materials for thermocouples. A. SCHULZE. *Metallwirtschaft*, **18** [12] 249–54; [13] 271–76; [15] 315–20 (1939).—S. gives an exhaustive treatise on all metals and alloys which have been used and tried for combinations in thermocouples, together with curves of thermal forces as a function of temperature, and describes their properties and peculiarities. Measuring methods and principles involved are explained. Re, Os, W, and Mo are especially suitable for alloying with Pt, as they give a higher e.m.f. than Rh. An element of Rh-Pt against Re has, at 1600°C, an e.m.f. of 18 mv. and can be used up to 1800° if the couple is enclosed in a refractory mass of Al_2O_3. Up to 1900°C, a couple of Rh and Rh/Re alloy with 8% Re can be used. The Physik. Tech. Reichsanstalt employs a thermocouple of pure Ir and Ir with 10% Ru for temperatures up to 2000°C. An element, for the same range, of Ir with 10% Ru against IrRh with 60% Rh gives still higher thermal forces. An element of 75% W and 25% Mo against a pure W wire will stand 3000°C, but the e.m.f. is only 5.8 mv. at 2570°. Pure W against Mo plus 1% Fe is somewhat better. S. describes theoretical investigations of what can be expected of metals and alloys for forming thermocouples. 34 references. M.H.

Moisture due to combustion and its effects on drying. C. F. MAYER. *Ind. Heating*, **6** [6] 535–40, 562 (1939).—M. discusses the possible adverse effect of the moisture (H_2O) developed in the combustion of fuel gases on a drying process and explains the combustion process theoretically by the reactions occurring. When all factors are considered, moisture due to combustion amounts, under average conditions, to about 1.7% of the absorption capacity of the circulating air; its effect on proper firing or drying, therefore, can be considered negligible. These conclusions are verified in practice where many gas-fired installations are used for core drying. M.H.

Normal oximes as flotation reagents. C. C. DEWITT AND FREDERICK VON BATCHELDER. *Jour. Amer. Chem. Soc.*, **61** [5] 1250 (1939).—Both heptaldoxime and octaldoxime are satisfactory reagents for the separation of oxide, carbonate, and sulfide ores of copper from siliceous gangue material. F.G.H.

Photoelasticity and design of apparatus. A. CALDWELL. *Jour. Roy. Tech. Coll.* [Glasgow], **4** (Part 3) [1] 501–15 (1939).—C. deals with the design of a polariscope suitable for laboratory and research work and compares the apparatus in use (glass plates, Iceland spar, Nicols, and Polaroid). Tension tests were made on models with square and round holes, and diagrams give approximate values for stresses in the material surrounding the holes. W.H.B.

Plate and frame filter press. PHILIP KRIEGEL. *Ind. Eng. Chem.*, **30** [11] 1211–13 (1938).—Illustrated. F.G.H.

Reactance of large rectangular three-phase electric furnaces. F. V. ANDREAE. *Trans. Electrochem. Soc.*, **67**, 151–68 (1935).—Tables are presented which permit the electric furnace designer to determine quickly the reactance of any large furnace of given dimensions and to calculate the characteristics of the furnace. Illustrated. F.G.H.

Rotary vacuum drying. L. H. BAILEY. *Ind. Eng. Chem.*, **30** [9] 1008–10 (1938).—The rotary vacuum drier consists of a stationary cylindrical steam-jacketed vessel in which an agitator revolves. A modification is the rotating vacuum drier in which the agitation is produced by revolving the cylindrical jacketed shell. The first-mentioned type is used whenever possible, as it is much more convenient to operate. The operating characteristics and economics of both types are discussed in detail. Illustrated. F.G.H.

Roto-louver drier. JOHN L. ERISMAN. *Ind. Eng. Chem.*, **30** [9] 996–97 (1938).—The general principles of the roto-louver design are outlined. Operating characteristics and applications are described and illustrated. F.G.H.

Safety glasses for eye protection. H. SAUERTEIG. *Oberflächentech.*, **16** [11] 112–14 (1939).—Safety glasses should preferably consist of three or more layers. Testing methods and German standards for safety glasses are described. M.H.

Screens in the process industries. ALBERT E. REED. *Ind. Eng. Chem.*, **30** [12] 1369–71 (1938).—Developments in the manufacture and application of various types of screen cloth are described and illustrated. F.G.H.

Selection of materials for crushing rocks. KENNETH LINDSAY AND HAROLD POLLITZ. *Machine Design*, **10** [3] 39–40 (1938).—Materials best suited for the parts of jaw and roll crushers are annealed electric steel castings with heavy reinforcing ribs for the main frame (inside surfaces machined), the same material for the one-piece pitman, 12 to 14% Mn steel for jaws and cheek plates, and cast iron for the remainder. J.M.N.

Sieving of fine dusts. A. M. BRYAN AND G. SCOTT. *Jour. Roy. Tech. Coll.* [Glasgow], **4** (Part 3) [1] 560–72 (1939).—The sieving of incombustible dusts used in coal mines is discussed, and the need for a specification governing the methods of sieving so that uniform results may be obtained is pointed out. Tests were made in which the weight of sample, moisture content, and type of dust were varied; the effects of these changes on sieving with a Rotap machine were noted. A method of sieving which gives results comparable with those of the Rotap machine is described, and graphs comparing the results obtained by sieving dusts by these methods are shown. W.H.B.

Simple apparatus for sedimentation analysis. N. A. FIGUROVSKII. *Zhur. Priklad. Khim.*, **10**, 1142–48 (1937).—F. describes a device for sedimentation analyses of suspensions and emulsions based on the principle of a hydrostatic self-regulating microbalance. Two modifications of its construction were worked out. In that for analyses of suspensions and emulsions, the velocity of sedimentation is determined with the aid of a float suspended on a fine platinum wire and immersed in the liquid. The float is a glass pivot of a length equal to the height of fall of the particles. The second modification presents a sedimentation balance working similarly to the Sven Oden apparatus and can be used for analyzing suspensions at small concentrations of the suspended matter (0.01 to 0.05%), making the use of stabilizers superfluous. P.B. & E.S.

Sintered-glass filters and bubblers of Pyrex-brand glass. HOSMER W. STONE AND LOUIS C. WEISS. *Ind. Eng. Chem., Anal. Ed.*, **11** [4] 220 (1939).—Although sintered-glass filters have many applications, their use has been limited by the lack of a commercial supply in borosilicate glass and of adequate directions and facilities for making them. The authors present a technique for sintered-glass preparation, requiring a minimum of skill and equipment. Illustrated. F.G.H.

Spray drying. W. S. BOWEN. *Ind. Eng. Chem.*, **30** [9] 1001–1002 (1938).—Spray drying consists primarily of the fine atomization of a liquid or slurry containing solids, either in solution or in suspension, in the presence of a desiccating medium in order to evaporate the liquid phase and leave the solid phase in free suspension in the gaseous phase consisting of the desiccating medium and the evaporated liquid phase. Secondarily, it consists of the removal of the solid phase in powdered form from the gaseous and vapor phase. The steps comprise producing the

desiccating medium, atomizing the liquid containing solids, bringing the two into contact in such a manner as to remove the moisture while all individual particles are in free suspension, and removing the dry solids from the system. Illustrated. F.G.H.

Spray drying. BEN B. FOGLER AND ROBERT V. KLEINSCHMIDT. *Ind. Eng. Chem.*, **30** [12] 1372–84 (1938).—In spray drying, a solution or slurry containing the desired solid material is continuously sprayed into a chamber and subjected to the action of a stream of drying gas, usually preheated air or diluted products of combustion. One of the most important aspects is the physical form of the product, which is usually granular; the individual particles are generally rounded in shape and hollow to a degree which is controllable over a rather wide range in the operation of the process. For many materials, a product in this form has important advantages, chiefly rapid solubility, lessened hygroscopicity, and unusual mobility in handling. The hollow form of the spray-dried particle usually gives a more bulky product than that obtained by other drying processes, which is an asset only when the spray-dried product commands a price which more than offsets the higher cost of packaging. Other important advantages of spray drying are the rapid rate and the relatively low material temperature at which drying is accomplished. A particle stays in the spray-drying chamber about 15 to 30 sec. when passing from liquid to solid form; the particle temperature need not rise materially above the wet-bulb temperature of the liquid of the solution. A bibliography of patents is included. Illustrated. F.G.H.

SEPARATE PUBLICATION

Conclusions from Experiments in Grinding. WILL H. COGHILL AND FRED D. DEVANEY. *School Mines & Met. Univ. Missouri Bull., Tech. Series*, **13** [1] 102 pp. (Sept., 1938).—The theory and practice of mill grinding is discussed in detail. Important items which must be considered in order to produce fine-grained material at a minimum cost are given. The principles of ball milling will never be brought down to the handbook system; the experimenter will have to learn how to take into account all the set and induced variables. P.G.H.

PATENTS

Air filter. FRANK L. MYERS (Owens-Illinois Glass Co.). Can. 381,902, June 6, 1939 (April 10, 1937). G.M.H.

Automatic cutter for roofing tile. GRETE STORCH RUNGE. Ger. 666,240, Sept. 22, 1938 (Nov. 3, 1934); VI/80*a*. 37. D.A.B.

Fluid pressure control device. GEORGE G. MORIN AND EMILE J. CARLETON. Can. 381,481, May 23, 1939 (May 21, 1937; in U. S. June 13, 1936). G.M.H.

Sandblast device. LESLIE L. TIRRELL (Hydro-Blast Corp.). Can. 381,286, May 9, 1939 (Aug. 4, 1937). G.M.H.

Sedimentation tank. NELS B. LUND (Dorr Co., Inc.). Can. 381,880, June 6, 1939 (Oct. 12, 1937). G.M.H.

Wire cutting press for clay, etc., with blades moving in a counter direction on an endless chain. ANTON DIETZ. Ger. 674,436, March 23, 1939 (Jan. 4, 1937); VI/80*a*. 26.—A wire cutting press is provided with blades moving in a counter direction and meshing into the spaces between the augers of an endless screw. The counter-moving blades are caused to move in the guiding slots for the links of the chain oblique to the direction of motion of the chain. D.A.B.

Kilns, Furnaces, Fuels, and Combustion

Determining the sediment content of fuel oil. S. H. HULSE AND H. L. THWAITES. *Ind. Eng. Chem., Anal. Ed.*, **10** [12] 678–80 (1938).—A practical method has been developed for determining the sediment content of residual fuel oil without the use of a diluent which may dissolve or disperse nonfilterable material. The method is useful in predicting the storage performance of fuel oils and may be of value in determining the tendency toward fouling of preheaters. Illustrated. F.G.H.

Effect of pressure on viscosity of *n*-butane and isobutane. B. H. SAGE, W. D. YALE, AND W. N. LACEY. *Ind. Eng. Chem.*, **31** [2] 223–26 (1939).—The viscosity of *n*-butane and isobutane was measured throughout the gaseous region at temperatures of 100° to 220°F. The viscosity of these hydrocarbons of the liquid phase was also determined throughout this temperature interval from vapor pressure up to 2000 lb./sq. in. Tables and diagrams are given. F.G.H.

Effect of temperature and duration of firing on the formation of mullite. V. B. KRAFT AND T. A. GURVICH. *Ogneupory*, **3** [10] 798–801 (1935).—Mullite is formed rapidly during the firing of clay, and considerable amounts are present at 1100°. It is formed very rapidly in Chasov-Yar clays. The temperature of firing determines the degree of mullitization; a maximum mullitization is obtained after a 2-hr. firing. The duration of firing determines the size of mullite crystals formed. Alkalis promote mullitization and increase the rate of growth of the mullite crystals. The amount of mullite obtained depends directly on the alumina content of the clay. M.V.C.

Electric furnace for metal hardening. ANON. *Maschinenbau*, **18** [7–8] 43 (1939).—A general discussion of recent electric furnaces is given. Furnaces used up to 1350°C are described. C.H.R.

Fusion point of coal ash. J. HAMILTON AND W. MILLER. *Jour. Roy. Tech. Coll.* [Glasgow], **4** (Part 3) [1] 573–86 (1939).—Fusion tests were made of various coals under reducing atmosphere conditions, and observations were made of changes taking place as the temperature was increased: (1) color of the ash (*a*) as incinerated, (*b*) as ground, and (*c*) as paste and (2) appearance of the residue from the fusion test. A few photomicrographs of fused and partially fused ash are shown. It appears from experiment that the mineralogical composition might be of greater service than chemical analysis in predicting fusion points. The material which produces the ash of a coal is usually considered a mixture of kaolin with quartz, feldspars, amphiboles, pyroxenes, calcite, ankerites, and pyrites. The SiO_2 reported in an analysis might be partly from kaolin, silica, or silicates. The original combinations of the constituents must have an influence on the fusion. See *Ceram. Abs.*, **18** [4] 115 (1939). W.H.B.

Kiln-car setting is furnace on wheels. ANON. *Ceram. Ind.*, **27** [5] 340–41 (1936).—The Locke Insulator Corp. uses an open-fire setting built entirely of silicon carbide to increase kiln capacity and decrease fuel consumption. The two longitudinal sections of the car are permanent structures of silicon carbide posts and slabs, while the center portion is composed of removable silicon-carbide trays. Other factors which increase efficiency and capacity of the plant are briefly described. E.J.V.

Liquid-phase hydrogenation of Pittsburgh seam coal. L. L. HIRST, C. O. HAWK, G. C. SPRUNK, P. L. GOLDEN, I. I. PINKEL, R. L. BOYER, J. R. SCHAEFFER, R. H. KALLENBERGER, H. A. HAMILTON, AND H. H. STORCH. *Ind. Eng. Chem.*, **31** [7] 869–77 (1939).—Quantitative procedures for the hydrogenation assay of American coals have been developed. This work involved the perfection of mechanical equipment for continuous operation of the experimental plant and the development of feasible quantitative tests. All work was done with Pittsburgh seam coal from the Bureau of Mines experimental mine at Bruceton, Pa. The assay work on this coal has been completed. Data are presented concerning the effect of varying temperature, contact time, agitation, and pressure. Illustrated. See *Ceram. Abs.*, **17** [5] 195 (1938). F.G.H.

Phase equilibria in hydrocarbon systems: XXIV, Latent heat of vaporization of propane and *n*-propane. B. H. SAGE, H. D. EVANS, AND W. N. LACEY. *Ind. Eng. Chem.*, **31** [6] 763–67 (1939).—The latent heat of vapori-

zation was measured experimentally for propane at temperatures from 100° to 170°F and for *n*-propane from 80° to 200°F. The apparatus employed is described in detail. The results are presented in both tabular and graphical form. The results obtained are compared with the data of other investigators. For Part **XXI** see *Ceram. Abs.*, **17** [10] 337 (1938). F.G.H.

Theory of firing refractories. L. M. BLYUMEN. *Ogneupory*, **3** [8] 611–15 (1935).—Conclusions of Russian writers on the firing of refractories are criticized. See *Ceram. Abs.*, **14** [5] 124 (1935). M.V.C.

BOOK AND SEPARATE PUBLICATIONS

Analyses of Pennsylvania Bituminous Coals. GEORGE H. ASHLEY, ALBERT L. TOENGES, ROBERT L. ANDERSON, W. E. RICE, C. M. STULL, N. H. SNYDER, R. J. SWINGLE, H. M. COPPER, AND R. F. ABERNETHY. *U. S. Bur. Mines Tech. Paper*, No. 590, 503 pp. Price 50¢.—Analytical data on the composition and quality of the coals of the state are given together with a description of the geologic structure of the coal basins, typical mining conditions in the different districts, and principal economic data of the industry. R. A. HEINDL

Combustion, Flames, and Explosions of Gases. BERNARD LEWIS AND GUENTHER VON ELBE. Macmillan Co., New York, 1938. 415 pp. Price $5.50. Reviewed in *Jour. Amer. Chem. Soc.*, **60** [8] 2011 (1938).—The authors present an excellent example of the application of the chain concept to the general field of combustion and in particular to that of hydrogen, carbon monoxide, and the hydrocarbons. The theoretical foundations of the chain theory are discussed together with the chain reactions of oxidation of the above-mentioned gases. Emission spectra and ionization, ignition by sparks, propagation of flames, influence of vessel shape and motion variables on these flames, stationary and diffusion flames, and the theory of burning velocity and detonation are dealt with. The state of the burned gas, important thermodynamic features being stressed, and problems in technical combustion, including industrial heating and internal combustion engines, are also discussed. F.G.H.

Methods of Analyzing Coal and Coke. F. M. STANTON, A. C. FIELDNER, AND W. A. SELVIG. *U. S. Bur. Mines Tech. Paper*, No. 8, 59 pp. Revised ed. Price 15¢. Methods used by the Bureau of Mines for analyzing coal and coke and determining their heating value and specific gravity are discussed. Methods for the determination of sulfur forms and carbon dioxide in coal and the agglomerating index of coal are given. R.A.H.

PATENTS

Electrical heating elements for obtaining high temperatures. SIEMENS-SCHUCKERTWERKE A.-G. Ger. 673,958, March 16, 1939 (Aug. 20, 1936); VIII*c*/21*h*. 2.02.—Electrical heating elements for obtaining high temperatures in furnaces such as porcelain-firing furnaces are provided with a gastight closed protective shaft or tube of ceramic material which surrounds the heat conductor with a spacing which is filled with an inert gas. This gas, *e. g.*, nitrogen or helium, has a pressure below that of the atmosphere at room temperature and approaching that of the atmosphere at operating temperatures. D.A.B.

Firing porcelain or other sintered ceramic materials electrically. PORZELLANFABRIK KAHLA. Ger. 673,674, March 9, 1939 (Nov. 3, 1931); V/80*c*. 17.50. Addition to 623,993 (*Ceram. Abs.*, **16** [11] 348 (1937)).—Porcelain or other sintered ceramic materials are fired electrically at a temperature above that of the decomposition of the iron oxide in the presence of introduced reducing gases according to Ger. 623,993. A mixture of carbon monoxide and carbonic acid in proportions of about 2 to 1, which is diluted by the admixture of over 80% of nitrogen gas, is employed within the temperature range 950° to 1150°C. D.A.B.

Ovens or kilns for use in the manufacture of earthenware tile, brick, etc. H. R. HOLDING. Brit. 506,586, June 14, 1939 (Nov. 29, 1937).

Producer gas plant. J. A. MACDONALD. Can. 381,641, May 30, 1939 (Oct. 6, 1937). G.M.H.

Geology

Adsorptive properties of clay (kaolin). V. I. NIKOLAEV AND E. I. RUDENKO. *Compt. Rend. Acad. Sci. U.R.S.S.*, **21**, 237–39 (1938).—With a very pure sample of kaolin, a molecular adsorption of Na and K chlorides and bromides, probably in the form of NaCl(Br) and KCl(Br), was observed; there was no adsorption of Ca^{++}, Mg^{++}, or SO_4^{--} ions. The values of the adsorption of separate brine ions by a kaolin-containing (48.8% pure clay) mud complex are somewhat greater than those of the same ions by pure clay. The constancy of Cl-ion concentration can not possibly serve as a basis for estimating the age of natural water basins. P.B. & E.S.

Barite mining in southern Missouri. RUTH FITCH HOPSON. *Explosives Engr.*, **14** [4] 107, 113 (1936).—Details of production are described. Illustrated. F.G.H.

Bauxite and soils in the Turgai. D. N. BURTSEV. *Soviet. Geol.*, **8** [1] 87–88 (1938); *Chem. Abs.*, **33**, 4166 (1939).—The bauxite and red clay contain 49 and 29 Al_2O_3, 27 and 13 volatile matter, 12.2 and 30.5 SiO_2, 5.8 and 15.4 Fe_2O_3, and 5.5 and 2.25% TiO_2, respectively.

Blasting raw materials for steel. C. H. JOHNSON. *Explosives Engr.*, **16** [3] 71–89 (1938).—The production of dolomite for refractory service is described in detail. Illustrated. F.G.H.

Cambric clay, the raw materials base of the Leningrad region for the construction of brickworks. A. S. SLEPUKHIN. *Stroitel. Materialy*, **1938**, No. 8–9, pp. 5–10.—S. gives physicochemical and ceramic characteristics of blue cambric clay deposits that can be used for the production of brick and clinker. P.B. & E.S.

Composition and classification of "dissociating rocks." P. NIGGLI. *Schweiz. Arch. Angew. Wiss. Tech.*, **5** [1] 9–20; [2] 35–42 (1939).—Dissociating rocks are defined as rocks which dissociate while being dried, soaked, or floated. N. describes the different grain elements from the physical and chemical viewpoints and the dissociating rocks as a mixture of these grain elements. Illustrated. J.M.N.

Conditions governing the diffusion of water in clays. W. R. MORGAN AND R. K. HURSH. *Jour. Amer. Ceram. Soc.*, **22** [8] 271–78 (1939).

Deposit of bauxite in Siberia. L. A. RAGOZIN. *Razvedka Nedr*, **1938**, No. 10, pp. 18–22; *Chem. Abs.*, **33**, 4166 (1939).—The bauxite contains SiO_2 28.65, Al_2O_3 27.70, Fe_2O_3 23.74, FeO 0.85, Mn 0.34, TiO_2 2.90, P_2O_5 0.09, CaO 0.97, MgO 0.22, total alkali 0.67, and water (at 110°) 4.75%.

Empire supplies of kyanite. ANON. *Bull. Imperial Inst.*, **36** [4] 493–98 (1938).—Kyanite is being increasingly used for the preparation of refractories. Of the three natural minerals, sillimanite, kyanite, and andalusite, kyanite is the most important commercially because it occurs in large and easily workable masses capable of affording a considerable and steady supply of material of uniform grade. Kyanite changes into mullite at the lowest temperature of the three, and because of the manner in which the resultant mullite crystals interlock, kyanite is believed to give a stronger mechanical body than andalusite. In sillimanite and andalusite, the mullite crystals develop parallel to the direction of the *c* axis of the original crystal, but in kyanite the mullite needles grow inward perpendicular to the surface of the original grains. Most American kyanites, which are separated from the minerals present in the rock either by a wet process or by magnetic separation, screening, and tabling, are converted on firing into weak, small grains which will not serve satisfactorily as grog, whereas the Indian kyanite, which is of the massive type, affords a coarser grog and retains much of its strength after firing. Indian kyanite, therefore, is

the most popular at the present time, considerable quantities being imported. Statistics of the production of kyanite in India and exports for the last ten years are given. Small deposits occur in Ajmer-Merwara, Rajputana, and Mysore. The bulk of the output comes from Singhbhum in Bihar, 96% of which comes from Lepso Buru in Kharsawan State. In Singhbhum, the kyanite rock associated with quartz-kyanite rock occurs at intervals in a belt nearly 70 miles in length. At Lepso Buru (hill) enormous beds of kyanite-quartz rock contain segregations of massive kyanite. Kyanite has recently been discovered in Nyasaland. A large new deposit has been found between Dzonze Mountain and Kapiridimba on the Kirk Mountains plateau within 20 miles of the railway. Samples of Nyasaland and Indian kyanites analyzed as follows:

	Nyasaland	Indian
Al_2O_3	58.19	65.52
SiO_2	36.71	31.07
TiO_2	1.27	1.43
Fe_2O_3	0.86	1.50
CaO		0.34
MgO		0.04

Deposits of kyanite in British East Africa may be regarded as potential resources. Kyanite of good quality occurs in a deposit discovered in Kenya, details of which are not available. Large quantities are reported from south of Lake Karenge, Ankole district, Uganda. Kyanite is extremely abundant in the Chittering Valley in Western Australia, 40 miles from Perth. There are millions of tons of rocks carrying 10 to 40% of kyanite, from which a pure kyanite concentrate can easily be obtained. A.P.S.

Exploring down. SHERWIN F. KELLY. *Explosives Engr.*, **13** [9] 263–70; [10] 303–12 (1935).—The magnetic and gravitational methods of geophysical prospecting for both metallic and nonmetallic minerals and petroleum are described in detail. Illustrated. F.G.H.

Explosives theory for the geophysicist. H. E. NASH AND J. M. MARTIN. *Explosives Engr.*, **14** [7] 209–13 (1936).—The significance of some fundamental properties of explosives, with special reference to geophysical prospecting, is discussed. Illustrated. F.G.H.

Geology of raw materials for porcelain production. EVŽEN STACHA. *Zprávy České keram. společnosti*, **15** [1–2] 46–52 (1938).—Karlsbad kaolin is the general name for the material from the region of Sedlec-Chodov reaching from Ostrov to Falknov. The deposits originated by transformation of granitic rocks of Karlsbad and Neudeck-Eibenstock. The deposits are partly of primary and partly of secondary origin and are 20 to 30 m. thick. The kaolin of Kadaň originated by kaolinization of gneiss and is the primary kaolin. The average thickness of the deposit is 30 m. The kaolin deposits of Plzeň, Horní Bříza, Třemošná, Vorlík, Sence, Dobřany, Chlumčany, and Kaznějov originated by transformation of the Permocarboniferous arkoses and are about 60 m. thick. In Moravia in the region of Svratka, in the valley of Bílý Potok (White Creek) between Maršov and Lažánky, the kaolin originated by influence of the humic acid and carbonic acid on the gneiss. In Eastern Slovakia in the region of Dubrinič and Perečin, kaolin of excellent quality originated by washing over into the Miocene. The deposits of feldspar are found chiefly in Teplá, Konstantinovy Lázně, Poběžovice, Meclov, Ronšperk, Zámělice, and Otov. Quartz is found everywhere near the kaolin deposits.

Heat of dehydration of clay. G. O. GROSS. *Ogneupory*, **3** [8] 606–10 (1935).—The study of published data on the pyrochemical reactions produced during the heating of clays showed a great variety, which is accounted for by the different nature of the clays studied. M.V.C.

Investigation of the structure of kaolin by means of electron diffraction. G. Z. PINSKER. *Zhur. Tekh. Fiz.*, **8** [13–14] 1226–28 (1938).—P. reviews experimental results and concludes that, in order to determine the structure of kaolin with electron diffraction methods, the material under investigation must be finely divided. B.Z.K.

Italian bentonite. FRANCESCO SAVELLI. *Mat. prime ital. imp.*, **3**, 129–37 (1938); *Rev. géol.*, **18**, 574 (1938); *Chem. Abs.*, **33**, 4166 (1939); see *Ceram. Abs.*, **16** [7] 217 (1937).

Lattice constants and space group of wagnerite, $Mg(MgF)PO_4$. O. KRAUS AND F. MUSSGNUG. *Naturwissenschaften*, **26** [49] 801–802 (1939).—This mineral shows the following constants: a = 11.90 Å, b = 12.51 Å, and c = 9.63 Å; it has an axis relationship of $a:b:c$ = 0.9512: 1:0.7697; B = 108°7′. C.H.R.

Mineral development in Soviet Russia. C. S. FOX. *Trans. Mining Geol. Met. Inst. India*, **34** [2] 98–201 (1938).—F. gives an account of Russia's present mineral position from data obtained during the 17th International Geological Congress held in the Soviet Union in July, 1937, including a brief history of the Russian geological surveys from 1882 to the present time. A.P.S.

Mineral resources of the chemical industries. R. N. KELLER AND T. T. QUIRKE. *Econ. Geol.*, **34** [3] 287–96 (1939).—The geologic origin of the constituents of 150 important industrial chemicals was determined. Selection was made on the basis of quantity consumption and use in a large variety of essential products. In the majority of cases, one chemical is produced by the use of a group of other chemicals. The same raw materials enter into the manufacture of many industrial chemicals. The importance of hydrocarbons, sulfur and sulfides, the haloid salts, and limestone is emphasized. Tables list the chemicals and the 34 geologic raw materials required in their preparation. J.L.G.

Origin of kaolin. P. A. ZEMYATCHENSKIĬ. *Compt. Rend. Acad. Sci. U.R.S.S.*, **20**, 471–73 (1938).—Chemical and optical investigation of a greenish scaly mineral found in a kaolin deposit showed it to be the result of secondary alterations of biolite forming a constituent of local gneiss-granites. P.B. & E.S.

Physical chemistry of the soil. H. PALLMANN. *Schweiz. Arch. Angew. Wiss. Tech.*, **5** [3] 61–73 (1939).—A highly theoretical research is presented with a bibliography and 21 tables. Illustrated. J.M.N.

Purification of Indian bauxite. U. CHATTERJEE, B. C. ROY, AND H. N. DAS GUPTA. *Indian Ceramics*, **1** [2] 65–68 (1938).—Large quantities of raw bauxite are exported annually from India, but owing to its low alumina content the price is very low. Preliminary laboratory experiments made by the authors to study the feasibility of purifying Indian bauxite by the Bayer process to make it suitable for aluminum extraction or for refractory purposes are presented. The cost of purifying bauxite for refractory purposes would be prohibitive, but this could be offset to some extent by the recovery of important impurities (compounds of iron, titanium, and silica) in usable form. The high titania content of Indian bauxite reduces its refractoriness, and because of the wide industrial application of titania it was isolated in a pure form simultaneously with the purification of the crude bauxite. The iron left in the residue was recovered in the form of a pigment. It was precipitated as ferrocyanide and subsequently oxidized to Prussian blue. The alumina recovered gave the following analytical value: Al_2O_3 99.3, Fe_2O_3 none, TiO_2 none, SiO_2 0.20, and Na_2O 0.30%. Only 20% of the total titania content could be recovered. The process will be commercially successful only when alumina is used for the extraction of aluminum metal and not when alumina is used as a refractory. A.P.S.

Refractory clays of Arctic Siberia. A. D. FEDOSEEV. *Ogneupory*, **6** [10] 1553 (1938).—Samples of clays and kaolin from the Omsk region, Siberia, are of high grade. Clays and kaolins from this part of Siberia may be used in ceramic products. Data on their properties are tabulated. M.V.C.

Story of sillimanite. ANNA MCNEIL. *Explosives Engr.*, **15** [4] 117–19 (1937).—The production of andalusite in the Inyo Mountains, in Mono County, Calif., is described and illustrated. F.G.H.

Synthesis of anorthite by pneumatolysis by means of explosives. A. MICHEL-LÉVY AND J. WYART. *Compt.*

Rend., **208** [13] 1030–33 (1939).—In a manner similar to the synthetic reproduction of the alkaline feldspars, orthoclase and albite (*Ceram. Abs.*, **18** [7] 195 (1939)), the synthesis of the purely calcic plagioclase feldspar, anorthite, was accomplished by the explosion of hexogen into which a mixture of 0.12 g. precipitated Si, 0.05 g. alumina, and 0.08 g. $CaCO_3$ was introduced. The procedure is described in detail. M.H.

Synthesis of quartz by pneumatolysis with the aid of explosives. Formation of liquid inclusions. A. Michel-Lévy and J. Wyart. *Compt. Rend.*, **208** [20] 1594–95 (1939).—By modifying the conditions of their experiments to produce feldspar (see preceding abstract), the authors produced quartz in pyramided prisms 0.4 mm. in length and 0.1 to 0.2 mm. thick by exploding hexogen in a crucible. It is suggested that the conditions applied in the experiment approach closely those prevailing in nature at the origin of granite minerals. M.H.

Trends in geochemistry. Roger C. Wells. *Jour. Chem. Education*, **15** [11] 524–32 (1938).—W. describes the past work of the Geological Survey and traces the development of the geochemistry of Clark, Hillebrand, and Washington to the present time. P.G.H.

X-ray investigation of ceramic clays. J. Ehlers. *Z. Angew. Mineral.*, **1**, 397–416 (1939); *Chem. Abs.*, **33**, 4751 (1939).—Clays, mainly of Tertiary age, from middle or southern Germany, were analyzed mechanically into 6 portions of average size from under 2μ to 1 mm. The three finest fractions (2μ to 0.01 mm.) were examined in X-rays, the finest in most detail. Results show that apart from the quartz, which occurs mainly in the coarsest fractions (above 0.02 mm.), the proportion of kaolinite increases fairly steadily while that of mica and of montmorillonite steadily decreases as the geological age of the deposit increases. The variation in the relative amounts of mica may indicate gradual climatic change. Detailed results are given for 17 clays.

Zircon and rutile from beach black sand deposits. W. R. Poole. *Chem. Eng. & Mining Rev.*, **31** [365] 216 (1939).—Deposits of black sand containing zircon, rutile, ilmenite, garnet, monazite, and cassiterite that occur on the beaches of New South Wales are concentrated by nature through the action of the waves during storm periods. The lighter quartz sand is largely removed, leaving one or more layers of the black sand varying in thickness from 1/4 in. to 3 to 4 ft., with silica sand lying between the layers. These deposits may be present in areas up to 80 ft. in width and one mile in length. The natural concentrate has approximately the following composition: 45 to 75 zircon, 20 to 30 rutile, and 10 to 20% ilmenite. A similar concentrate may be obtained from the sand dunes by tabling and washing. B.C.R.

BOOK AND SEPARATE PUBLICATION

Chromite. Robert H. Ridgway. Preprint from U. S. Bur. Mines Minerals Yearbook, 1939. 10 pp. Govt. Printing office, Washington, D. C. Price 5¢. R.A.H.

Quartz Family Minerals. H. C. Dake, F. L. Fleener, and B. H. Wilson. Whittlesey House, McGraw-Hill Book Co., New York, 1938. 304 pp., 52 illustrations. Price $2.50. Reviewed in *Econ. Geol.*, **34** [3] 352 (1939).—The various forms of quartz are considered, and the numerous varieties of each form are described. Occurrences and localities are given. A chapter is devoted to the cutting and polishing of gem quartz. J.L.G.

PATENT

Clay reactivation. George Hugo von Fuchs (Shell Development Co.). Can. 381,583, May 23, 1939 (March 22, 1937; in U. S. April 15, 1936). G.M.H.

Chemistry and Physics

Catalytic effect of anions upon the rate of dissolution of hydrous alumina by acids. John P. Clay and Arthur W. Thomas. *Jour. Amer. Chem. Soc.*, **60** [10] 2384–90 (1938).—Certain anions, *viz.*, fluoride, phosphate, phosphite, oxalate, and sulfate, or their acids, greatly accelerate the rate of dissolution of hydrous aluminum oxide in 0.2 molar hydrochloric acid solution even when present at a concentration of 0.001 molar. This phenomenon can not be explained on the basis of increased acid strength, increased diffusibility of the acid, valence of the anion, or general acid-base catalysis. An explanation based on the coördination structure of the hydrous oxide and the formation of a complex at the solid-liquid interface has been offered. Illustrated. F.G.H.

Crystalline structure of intermetallic compounds of aluminum with titanium, zircon, thorium, niobium, and tantalum. C. Brauer. *Naturwissenschaften*, **26** [43] 710 (1938).—B. studied $TiAl_3$ with $a = 5.425$ Å, $c = 8.579$ Å; $NbAl_3$ with $a = 5.427$ Å, $c = 8.584$ Å; $TaAl_3$ with $a = 5.422$ Å, $c = 8.536$ Å; $ZrAl_3$ with $a = 4.00$ Å, $c = 17.3$ Å, having 16 atoms per cell in the tetragonal system; and $ThAl_3$ with $a = 6.48$ Å, $c = 4.601$ Å, having 8 atoms per cell in the hexagonal system. $NbAl_3$ and $TaAl_3$ form solid solutions with each other. C.H.R.

Densities of fine powders: II. J. L. Culbertson and Martin K. Weber. *Jour. Amer. Chem. Soc.*, **60** [11] 2695–97 (1938).—Density measurements of silica and charcoal, with a series of liquids as the buoying fluid, indicate that polar liquids yield high density values for silica and nonpolar liquids yield low values. The more compressible liquids yield the higher density values for charcoal. Polar liquids having large compression coefficients yield high density values for both solids. Density measurements of ground quartz of varying degrees of fineness were made with benzene and water as the buoying fluids. These measurements confirm the foregoing statements and indicate that a different degree of penetration of different liquids into the surface of the solid is probably of no significance in the variation of apparent density. F.G.H.

Determination of Fe_2O_3 in refractory materials. N. O. Zeldin and S. T. Balyuk. *Ogneupory*, **6** [10] 1552 (1938).—Fe_2O_3 is determined according to the method of Z. Reinhard by melting the sample with soda or $KNaCO_3$ in a platinum crucible. The disadvantage of this method is the transfer of small amounts of platinum into the melt. The use of NaOH and melting in a silver crucible are recommended. M.V.C.

Determination of iron in iron chromite. B. A. Sosnovskiĭ and Yu. I. Usatenko. *Zavodskaya Lab.*, **7**, 1192–94 (1938).—The ore is decomposed by a mixture of sulfuric and phosphoric acid. The separation of trivalent iron from the solution was not successful. All iron, therefore, was reduced to bivalent iron with zinc, which proved to be expedient. P.B. & E.S.

Determination of nickel and cobalt in silicate rocks. E. B. Sandell and R. W. Perlich. *Ind. Eng. Chem., Anal. Ed.*, **11** [6] 309–11 (1939).—A method for the determination of nickel is based on the extraction of nickel dimethylglyoxime with chloroform from the ammoniacal citrate solution of the rock sample. By shaking the chloroform extract with dilute hydrochloric acid, the dimethylglyoxime compound is decomposed and nickel is brought into the aqueous phase in which it is then determined colorimetrically by Rollet's method. This method is particularly designed for rocks of such low nickel content that the nickel can not well be determined by the gravimetric method of Harwood and Theobald. The method for the determination of cobalt in silicate rocks is based on the extraction of the element with a carbon tetrachloride solution of dithizone from the ammoniacal citrate solution of the sample. The carbon tetrachloride extract, which also contains the dithizonates of copper and other heavy metals, is evaporated to dryness, the residue is ignited to destroy organic matter, and the metal oxides are dissolved in aqua regia. The solution is treated with stannous chloride to reduce copper to the cuprous condition, and

cobalt is then determined colorimetrically by the addition of ammonium thiocyanate and acetone, essentially according to the directions of Tomula. Nickel accompanies cobalt in the dithizone separation, but because of the low concentration it usually does not markedly affect the determination of cobalt even when the ratio of nickel to cobalt in the final solution is 10 to 1. Alternatively, cobalt can be determined by the thiocyanate-amyl alcohol method, in which large amounts of nickel do not interfere. By using a 1-g. sample, 0.0001% of cobalt can be detected by either method. F.G.H.

Determination of potassium with hexanitrodiphenylamine (dipicrylamine) reagent. I. M. Kolthoff and Gordon H. Bendix. *Ind. Eng. Chem., Anal. Ed.*, **11** [2] 94–98 (1939).—Gravimetric and volumetric procedures are given for the determination of macro quantities and micro quantities of potassium as dipicrylaminate; a colorimetric procedure for the determination of micro quantities (10 to 100 gamma) is also presented. Illustrated. F.G.H.

Determination of silica with the aid of oxyquinoline in lead- and copper-melting slags. L. B. Ginzburg. *Zavodskaya Lab.*, **7**, 1041–43 (1938).—The method of Volynets and Bernstein (*Ceram. Abs.*, **16** [11] 359 (1937)) was adapted to the determination of silica in lead- and copper-melting slags. Sodium peroxide was used instead of soda for fusion with the sample. P.B. & E.S.

Determination of silica in the presence of fluorine salts. A. A. Vasil'ev and L. L. Lapchinskaya. *Zavodskaya Lab.*, **8**, 27–31 (1939).—After checking existing methods, the authors suggest a method combining the features of the P. Jannasch and H. Weber and the A. A. Borkovskiĭ and N. A. Krasilnikova methods. Good results were also obtained with the N. A. Tananaev and A. K. Babko method. P.B. & E.S.

Determination of small quantities of boron. Kenneth L. Robinson. *Analyst*, **64** [758] 324–28 (1939).—R. describes in detail a method for colorimetrically determining small amounts of boron. The intensity of the red color, developed by turmeric, is estimated by means of a Lovibond tintometer. The ordinary colorimeter is not satisfactory, owing to the presence of varying amounts of unchanged yellow turmeric which necessitates the use of an instrument capable of eliminating differences in tint. B.C.R.

Determination of strontium in the presence of calcium. R. Norris Shreve, C. H. Watkins, and J. C. Browning. *Ind. Eng. Chem., Anal. Ed.*, **11** [4] 215 (1939).—Calcium and strontium, when in the form of nitrates, may be separated quantitatively by virtue of the solubility of calcium nitrate in anhydrous acetone. F.G.H.

Determination of zirconium by weight by atoxyl. R. Chandelle. *Bull. Soc. Chim. Belg.*, **48** [1] 12–32 (1939).—C. describes a new method for the determination of Zr in metals, alloys, and soil containing Zr and Ti by means of atoxyl (sodium para-aminophenylarsenate). A white voluminous precipitate is produced. The sensitivity of the method is very great; amounts of 0.00000075 g. can be detected in a solution even in the presence of other metals. The precipitation is quantitative in solutions of normal HCl solutions. The exact procedure is given. M.H.

Determining SiC in carborundum. A. I. Miklashevskiĭ. *Zavodskaya Lab.*, **7**, 1433–34 (1938).—The method is based on the use of a small sample (0.05 g.) which is treated with HF acid with a few drops of H_2SO_4, ignited at a moderate temperature, and fused with 0.5 g. soda. Concentrated HCl (5 to 10 drops) is added, and the contents of the crucible are evaporated on a boiling water bath. After elimination of HCl and dehydration of SiO_2, the contents are moistened with 5 to 10 drops of concentrated HCl and left to stand 3 to 5 min.; hot water is added and the mixture is heated 2 to 3 min. by an electric heater, filtered, washed, and ignited as usual. The SiO_2 obtained is calculated to SiC, the factor being $^1/_2$. P.B. & E.S.

Determining Zn and Cd in yellow glasses. A. S. Aruina. *Zavodskaya Lab.*, **8**, 105–106 (1939).—The separation of Cd from Zn is effected with the aid of the Reinecke salt in the presence of thiourea. Small amounts of Cd can be determined when considerable amounts of Zn are present. P.B. & E.S.

Discussion of methods of analysis of silicates and silicate products. M. Bozsin. *Bull. Amer. Ceram. Soc.*, **18** [7] 242 (1939).

Ferromagnetic modification of iron oxide (III). O. Glemser and E. Gwinner. *Naturwissenschaften*, **26** [45] 739 (1938).—A new iron oxide (III) was isolated by oxidizing a ferrosalt alkaline solution, which showed a different X-ray diagram than that for α-Fe_2O_3 or γ-Fe_2O_3. A hexagonal elementary cell having $a = 5.09$ Å and $c = 4.41$ Å was shown. After 3 hours' heating at 110°C, this oxide converts to α-Fe_2O_3. The designation δ-Fe_2O_3 is suggested for this new compound. C.H.R.

Fluorescent analysis of inorganic materials. C. E. White. *Ind. Eng. Chem., Anal. Ed.*, **11** [2] 63–66 (1939).—W. describes methods of fluorescent analysis and discusses applications, particularly with respect to mineral identifications. F.G.H.

Hydroxyanthraquinones as analytical reagents. Colorimetric determination of zirconium or hafnium. Herman A. Liebhafsky and Earl H. Winslow. *Jour. Amer. Chem. Soc.*, **60** [8] 1776–84 (1938).—With the aid of a photoelectric recording spectrophotometer, precise colorimetric methods for the determination of zirconium or hafnium in small amounts were developed. The methods involve lake formation with the hydroxyanthraquinone dyes. Hafnium and zirconium, while qualitatively indistinguishable, can be estimated in a known weight of sample provided other cations can be removed if they are present. The effect on lake formation of varying the acid concentration was studied. Interference by other cations is negligible unless they are present in excess. The decrease in lake formation caused by complex formation between zirconyl and sulfate ions was investigated. This decrease is sufficiently pronounced to warrant the belief that colorimetric methods could be used for estimating the anions, particularly fluoride, that form complexes of this kind. The scattering of light by the lakes, which are present as suspensions in the alcoholic dye solutions, was also briefly investigated. Dithizone, another colorimetric reagent that reacts with many cations, is several times more sensitive, but the hydroxyanthraquinones are simpler to prepare and keep and are capable of giving accurate results with the expenditure of less time and effort. Illustrated. F.G.H.

Identification of lines in qualitative spectrographic analysis. W. C. Pierce, O. Ramirez Torres, and W. W. Marshall. *Ind. Eng. Chem., Anal. Ed.*, **11** [4] 191–93 (1939).—Charts giving a wave-length scale, an iron arc reference spectrum, and analysis lines for 47 elements are constructed for the region 2500 to 5150 Å by the use of a quartz Littrow spectrograph. Directions are given for using the charts in spectrographic qualitative analysis. Reproductions of the charts may be used as accurate wavelength and analysis scales for any quartz spectrograph. Illustrated. F.G.H.

Lead oxides: II, Hydrous, normal, and active lead monoxides. G. L. Clark and W. P. Tyler. *Jour. Amer. Chem. Soc.*, **61** [1] 58–65 (1939).—The preparation and analysis of powder and small crystals of the hydrous oxide of lead are described. The product always has a composition giving the formula $5PbO \cdot 2H_2O$. X-ray diffraction studies of this hydrate with a wedge reflection camera and Cu-Kα radiation give the spacings for the lines of the diffraction pattern. By trial-and-error methods and a few logical assumptions, a very rough estimate of the unit-cell dimensions of the hydrate was made; the crystals were considered to be monoclinic. Density measurements and unit-cell dimensions lead to an approximation of 1 mol./unit cell. Studies of the preparation of oxides from the hydrate, normal lead carbonate, and basic lead carbonate at low and high temperatures are described. The low-temperature preparations result in a product which gives a highly distorted X-ray diffraction pattern of the red tetragonal form of PbO, usually contaminated with some of the yellow orthorhombic modification. High-

temperature decompositions of the hydrate and basic lead carbonate give undistorted patterns showing mixtures of red and yellow PbO. High-temperature decomposition of normal lead carbonate gives an undistorted pure red PbO. Comparisons of the catalytic activities of normal and distorted red PbO, yellow PbO, and the hydrate toward hydrogen-peroxide decomposition are described. The activity of the distorted product is much greater than that of the other products, and the difference can not be attributed to particle size. Activity of the distorted oxide is decreased by "annealing" of the sample, which is accompanied by a sharpening of the diffraction lines. Comparisons of the heats of reaction of the normal and distorted red PbO with concentrated perchloric acid show that the distorted red PbO possesses a 1 to 2% greater energy content than normal red PbO. Relative intensity measurements on the distorted and normal red PbO are compared, and the tabulated results show the great decrease in line intensities on the distorted PbO pattern. The active properties found for the distorted red PbO are reviewed, and calculations show that the distortion can not be accounted for on the basis of atomic displacements by directional stress or, except to a slight extent, on the basis of thermal agitation resulting from the increased energy content of the product. Activity, therefore, must reside in localized incompletely crystallized surface areas. An explanation of the formation of yellow PbO at temperatures far below the red to yellow transition temperature is postulated on the basis that lattice impurities, such as water, will cause a metastable form to appear in temperature regions in which it is not usually produced. Illustrated. See "Preparation—," *Ceram. Abs.*, **18** [2] 61 (1939). F.G.H.

Melting point of barium molybdate. H. A. LIEBHAFSKY, E. G. ROCHOW, AND A. F. WINSLOW. *Jour. Amer. Chem. Soc.*, **61** [4] 969 (1939).—The melting point of barium molybdate was found to be 1480 ± 5°C. F.G.H.

Methods of analyzing corundum. F. YA. GALAKHOV. *Zavodskaya Lab.*, **8**, 107–108 (1939).—The following methods of analysis can be applied to corundum: (1) colorimetric determination of silica, (2) oxine method of determining alumina, (3) gravimetric determination of silica with the use of gelatin, and (4) determination of CaO in the presence of SiO_2 (if the amount of SiO_2 is not over 10 to 15%). The gravimetric method is described in detail. P.B. & E.S.

Methods of representing distribution of particle size. J. B. AUSTIN. *Ind. Eng. Chem., Anal. Ed.*, **11** [6] 334–39 (1939).—No single method of plotting which is applicable to all materials has been found. Three methods, however, have proved successful for certain classes of substances. The most widely applicable method consists in plotting particle size on a logarithmic scale and cumulative per cent on an integrated probability scale; it gives satisfactory results for crushed or ground materials such as silica, granite, limestone, clay, sodium carbonate, and alumina. The Rosin-Rammler method, which plots size on a log scale and cumulative per cent on a log-log scale, has been notably successful with broken coal. The third method, which has only a limited applicability, consists in plotting size on a linear scale and cumulative per cent on the integrated probability scale. These methods have a possible application in the determination of a representative sample of a material whose composition varies with the size of lump and can be extended to distributions other than size, such as the variation with time of the composition of pig iron from a given furnace. Illustrated. F.G.H.

Order and changes in condensed phases. F. C. FRANK AND K. WIRTZ. *Naturwissenschaften*, **26** [43] 698–705 (1938).—The molecular theory in regard to crystalline changes in melts is discussed in detail. C.H.R.

Polytherms of the system Al_2O_3–Na_2O–H_2O at 30° to 200°. G. K. MAGARCHAK. *Legkie Metally*, No. 2, pp. 12–16 (1938); abstracted in *Chimie & Industrie*, **40** [6] 1119 (1938).—Between 30° and 90°, the stable phase resulting from the solution of $Al(OH)_3$ in the alkali is hydrargillite. Between 95° and 150° the transformation into boehmite occurs which is stable between 150° and 200°. The influence of temperature and NaOH concentration on the solubility of alumina is discussed. F.E.V.

Precipitation of nickel and cobalt sulfides in a crystalline state by hydrogen sulfide in the presence of pyridine. E. A. OSTROUMOV. *Ind. Eng. Chem., Anal. Ed.*, **10** [12] 693–94 (1938).—O. describes a method for the separation of nickel and cobalt from calcium, magnesium, and alkalis based on the precipitation of nickel and cobalt sulfides in a crystalline state from solutions containing pyridine. The ammonium salts have no influence. The presence in the solution of pyridine salt favors the formation of larger crystals. The separation is very clean, since the sulfides in the crystalline form possess a minimum adsorption capacity, and the precipitate settles well and is rapidly filtered. The crystalline sulfides are oxidized slowly and do not produce colloidal solutions; therefore the precipitate does not pass through the filter. The method may be used in the analysis of various materials, particularly for the determination of alkalis in nickel and cobalt salts. The use of the method simplifies and accelerates the analysis without creating difficulties or requiring special apparatus. F.G.H.

Qualitative separations on a microscale. Separations in the alkaline-earth group. A. A. BENEDETTI-PICHLER, WILLIAM R. CROWELL, AND CLARENCE DONAHOE. *Ind. Eng. Chem., Anal. Ed.*, **11** [2] 117–20 (1939).—The procedure of Noyes and Bray for the separation and analysis of the alkaline earth group was applied on a microscale. The quantities of the reagents were chosen to permit the analysis of 1.2 mg. of nonmetallic materials or 0.6 mg. of metals and alloys. The perchlorate ion, introduced by the use of perchloric acid as solvent, is removed before precipitation of the alkaline-earth group. Illustrated. See *Ceram. Abs.*, **18** [8] 223 (1939). F.G.H.

Quantitative microanalysis of silicates. A. K. BABKO. *Zavodskaya Lab.*, **7**, 1121–24 (1938).—SiO_2 is determined by the pyridine-silicomolybdate method from a 3- to 5-mg. sample. The other principal components can be determined in another sample (10 to 15 mg.). Alkaline metals are more successfully determined from an 8- to 10-mg. sample; otherwise, too high values are obtained owing to the transfer of small amounts of these metals from the glass apparatus and reagents. P.B. & E.S.

Reduction of selenious acid by thiocyanic acid. WILLIAM T. HALL. *Ind. Eng. Chem., Anal. Ed.*, **10** [7] 395–96 (1938).—In the determination of selenium qualitatively, ammonium thiocyanate is added to a boiling solution which is about 6 *N* in hydrochloric acid, to precipitate any selenium present as selenious acid. One part of selenium can be detected in 20,000,000 parts of solution. For quantitative purposes, the reduction of selenious acid by potassium thiocyanate and hydrochloric acid is not satisfactory because it is practically impossible to make the reduction take place in accordance with a single definite equation. F.G.H.

Sensitivity of the carbonate test for lithium. EARLE R. CALEY AND A. L. BAKER, JR. *Ind. Eng. Chem., Anal. Ed.*, **11** [2] 101–102 (1939).—Though the carbonate reaction for lithium is too insensitive at room temperature to be of much practical use, at 100°C it is as sensitive and useful as some other qualitative reactions. About 3 mg. is the least amount that can be detected by a macromethod, but by the application of microchemical technique a few tenths of a milligram can be detected. The other alkalis do not interfere with the test. Ammonium salts prevent precipitation and must be removed. Almost all other interfering cations may be conveniently removed by precipitation as carbonates in cold solution, and the test is then applied to the filtrate after it is concentrated to the proper volume. The carbonate test is the most nearly specific of the known precipitation reactions for lithium, but it is not so sensitive as tests based upon precipitation as aluminate, arsenate, fluoride, phosphate, stearate, or triple uranyl acetate. In spite of its comparatively low sensitivity, it may be useful for establishing the presence of lithium as an essential constituent of an

unknown material when the approximate amount present can not be satisfactorily determined by the usual flame or spectroscopic tests. F.G.H.

Separation of cobalt from manganese. J. G. FAIRCHILD. *Ind. Eng. Chem., Anal. Ed.*, **11** [6] 326–27 (1939).—Although cobalt phosphate alone is soluble in ammonia in the presence of manganese, both metals are quantitatively precipitated by ammonium phosphate unless citrate ions are present. As little as 2 mg. of cobalt can be quantitatively separated from 0.1 g. of manganese after the addition of 2 g. of citric acid, when the phosphate precipitation is made by the method of W. Gibbs in which manganese phosphate is slowly precipitated at boiling temperature by the addition of dilute ammonia. The concentration of manganese should not exceed 0.1 g. of manganese in 100 ml. containing 1 to 2 g. of ammonium phosphate and 20 g. of ammonium chloride. Ammonium citrate appears to act as a differential retarding agent by permitting only a partial retention of cobalt and only slightly retarding the precipitation of manganese. This permits a fairly clean-cut separation of the two metals in 1 to 3 precipitations of manganese phosphate. The color of the precipitate is helpful in judging the extent of separation. Pure manganese phosphate, which is flesh colored, becomes lilac in the presence of 1 mg. or more of cobalt. It is permissible to determine cobalt quantitatively as the sulfate, which may be dehydrated at 600°C without dissociation. Consistently accurate results were obtained with quantities up to 0.4440 g. of cobalt sulfate. It is advisable to reignite the sulfate as a check for constant weight without an intervening evaporation with water and to stir it with a platinum wire before ignition. This avoids decrepitation and gives the same final weight of cobalt sulfate as that obtained by evaporation with water. No manganese was found in the cobalt sulfate by the colorimetric test. Any cobalt retained by the manganese phosphate is conveniently determined colorimetrically as the blue cobalt chloride. The slight green color of cobalt blue, which is perhaps due to iron or other slight impurity, may be partly overcome by reduction with a little sodium sulfite. F.G.H.

Separation of cobalt and nickel from manganese by hydrogen sulfide in a solution containing pyridine and the pyridine salt of hydrochloric acid. E. A. OSTROUMOV AND G. S. MASLENIKOVA. *Ind. Eng. Chem., Anal. Ed.*, **10** [12] 695–96 (1938).—A method for the separation of cobalt and nickel from manganese is based on the fact that, from a hot solution containing a pyridine salt of hydrochloric acid and free pyridine, hydrogen sulfide quantitatively precipitates sulfides of cobalt and nickel in a crystalline state, while all the manganese remains in the filtrate. The sorption of manganese by sulfides of cobalt and nickel is so insignificant that with the most variable proportions of the above metals a complete separation may be secured as a result of a single precipitation. F.G.H.

Silica gels from various acids. Effect of concentration and mixtures on setting time. HERBERT L. DAVIS AND KENNETH D. HAY. *Jour. Amer. Chem. Soc.*, **61** [5] 1020–23 (1939).—Silica gels produced by mixing sodium silicate with varying concentrations of hydrochloric, sulfuric, phosphoric, and acetic acids set in a minimum time when the final system is at p_H 8 or is somewhat more alkaline. Departure from this zone of rapid setting produces a sharp rise in the time of set, except where a buffer action enters in the acid systems. All of these acids produce a series of rapidly setting gels in strongly acid systems. It has been shown that a small excess of hydrochloric acid causes the setting time to rise steeply to a sharp maximum and it appears that for the other acids similar closed curves exist. For mixtues of sulfuric acid with hydrochloric or acetic acid in which the total acid normality is kept constant, the time of set is not a linear function of the composition of the mixture. On increasing the concentration of acid added to sodium silicate, four types of systems exist: stable alkaline negative silica sols, rapidly setting gels, stable acid positive silica sols, and a second series of gels in concentrated acid systems. Illustrated. F.G.H.

Solid solutions of calcium and barium orthosilicates. N. A. TOROPOV AND P. F. KONOVALOV. *Compt. Rend. Acad. Sci. U. R. S. S.*, **20**, 663–64 (1938).—The binary orthosilicate system, Ba–Ca orthosilicates, was studied. Microscopical investigations showed a complete homogeneity and one phase for all samples. The index of refraction of the crystals obtained increased with the increase in concentration of barium silicate in solid solutions. The specific gravity of mixtures changed continuously with the change of concentrations of both components. The authors conclude that there is a continuous series of solid solutions in the series of Ba- and Ca-orthosilicates systems. P.B. & E.S.

Solubility and disintegration of aluminum oxides. G. F. HÜTTIG, G. MARKUS, AND E. FRANZ. *Przemysl Chem.*, **22** [11–12] 375–79 (1938).—Aluminum oxide compounds of different origins are analyzed in reference to their solubility in acids. D.A.B.

Specific heats at low temperatures of beryllium oxide and beryllium orthosilicate (phenacite). K. K. KELLEY. *Jour. Amer. Chem. Soc.*, **61** [5] 1217–18 (1939).—Specific-heat measurements of beryllium oxide and beryllium orthosilicate were made covering the temperature range 52.5° to 298.1°K. The entropies are $S_{298.1} = 3.37 \pm 0.05$ for beryllium oxide and $S_{298.1} = 15.4 \pm 0.1$ for beryllium orthosilicate (Be_2SiO_4). The value $\Delta F^\circ_{298.1} = -140{,}320$ is given as the free energy of formation of beryllium oxide. Illustrated. F.G.H.

Specific heats at low temperatures of crystalline ortho-, meta-, and disilicates of sodium. K. K. KELLEY. *Jour. Amer. Chem. Soc.*, **61** [2] 471–73 (1939).—Specific heat data covering the temperature range 52.5° to 298.1°K are presented for sodium ortho-, meta-, and disilicates in the anhydrous crystalline state. The corresponding entropies at 298.1°K have been determined as 46.8 ± 0.6, 27.2 ± 0.3, and 39.4 ± 0.6, respectively. The value $S_{298.1} = 17$ is suggested as an approximation to the entropy of sodium oxide and $\Delta F^\circ_{298.1} = -91{,}000$ as an approximation to the free energy of formation. Illustrated. F.G.H.

Spectrophotometric methods in modern analytical chemistry. S. E. Q. ASHLEY. *Ind. Eng. Chem., Anal. Ed.*, **11** [2] 72–79 (1939).—Spectrophotometry is a branch of physical chemistry sorely neglected by the analytical chemist. Its advantages lie in (1) elimination of comparison solutions, (2) direct calibration of an instrument by a few simple measurements, (3) ability to determine independently the constituents of a mixture of colored substances, (4) precise evaluation of the errors of a method, and (5) extension of measurements to the invisible regions of the spectrum. Speed is an advantage of colorimetric analysis not lost in spectrophotometric analysis. A. gives a brief résumé of the types of instruments available, the important errors and limitations of the present methods, and examples of the results obtainable with actual analytical problems. Illustrated. F.G.H.

Stannous chloride as a quantitative reagent for selenium and tellurium. W. R. SCHOELLER. *Analyst*, **64** [758] 318–23 (1939).—A process generally applicable for the determination of small amounts of selenium and tellurium is described in detail. It consists of the following manipulations: (1) acid attack, preferably HNO_3, or fusion with sodium peroxide and solution with HCl; (2) precipitation of the selenium and tellurium with ammonia on $Fe(OH)_3$, which should be present in an amount 30 to 50 times that of the selenium and tellurium, if copper or HNO_3 must be eliminated; (3) precipitation of the two elements with $SnCl_2$; (4) solution of the precipitate in brominated HCl; and (5) precipitation of the solution with SO_2 in two stages for the separation of the selenium and tellurium. No evaporations of chloride solutions and no precipitation with H_2S or extraction with alkaline sulfides are involved. B.C.R.

System FeO–TiO_2. J. GRIEVE AND J. WHITE. *Jour. Roy. Tech. Coll.* [Glasgow], **4** (Part 3) [1] 441–48 (1939).—The research investigation reported was intended primarily as a contribution to the study of the constitution and properties of ferrous slags. The thermal equilibrium diagram of FeO–TiO_2 was determined by means of thermal

analysis and microscopic examination. The melts were made by mixing various proportions of FeO and TiO_2, melting in Mo crucibles, and using W-Mo differential thermocouples. After the thermal study, each melt was sectioned, polished, and examined by reflected light. The most successful polishing method for extremely brittle specimens was hand polishing on finer grades of emery paper; the coarse papers caused excessive tearing of the sample surface. Specimens containing free FeO were etched with dilute HCl; for the others HF was necessary. The experimental procedures in heating the mixtures to consistent weight and the observations made during the tests are described at length. TiO_2 is considered to be slightly volatile at high temperatures in explanation of a slight loss of 0.5 to 0.8% by weight after several hours' heating to 1400° to 1600°C. Heating in a Pt crucible in air produced an orange-yellow coloration next to the crucible wall which indicated the formation of orange-yellow TiO_3 promoted by the absorption and release of O_2 by the Pt. In some of the melts in Mo crucibles, minute metallic dendrites were observable under the microscope in the vicinity of the crucible wall; these dendrites are considered to be similar to those observed by King (*Jour. Amer. Chem. Soc.*, **55**, 1376 (1933)) in ground-coat enamels. The results of microscopic examination appear to confirm the opinion that the O_2 content of an FeO melt in equilibrium with TiO_2 would be little, if any, in excess of that contained in FeO. The thermal equilibrium diagram is given and discussed with the evidence obtained from photomicrographs and X-ray powder patterns. The eutectic of FeO and $2FeOTiO_2$ at 1305°C with 95% FeO and 5% TiO_2 by weight, the high-temperature phase $2FeOTiO_2$ (pseudobrookite) at 1470°C, a eutectic $2FeOTiO_2$–$FeOTiO_2$ at 1320°C and 42% TiO_2 by weight, illmenite at 1470°C (approximately) at 52 to 56% TiO_2, and a eutectic at 1330°C for 68% TiO_2 consisting of FeO-TiO_2–TiO_2 (rutile) were determined. The X-ray patterns confirm the existence of the phases determined by the microscope and thermal data. Illustrated. W.H.B.

Trisodium phosphate-sodium fluoride. Phase studies and analytical methods. C. W. Mason and E. B. Ashcraft. *Ind. Eng. Chem.*, **31** [6] 768–74 (1939).—The supposed octahedral $Na_3PO_4 \cdot 10H_2O$ is shown by analysis and phase studies to be the double salt $NaF \cdot 2Na_3PO_4 \cdot 19H_2O$. This phase may appear in samples of trisodium phosphate containing as little as 0.1% sodium fluoride, an amount of impurity not uncommon. Depending upon temperature, within limited regions of the ternary diagram, either the octahedral double salt or the dodecahydrate may be the solid phase. A new isotropic phase stable in alkaline phosphate solution at 75° to 90°C is reported. Data showing that the fluoride ion is either strongly adsorbed on or contained in solid solution in trisodium phosphate dodecahydrate are presented. Analytical methods for the determination of small amounts of fluorine in the presence of phosphate are reviewed, and modifications of the volumetric thorium nitrate procedure are suggested. Illustrated. F.G.H.

Turbulence and diffusion. Hugh L. Dryden. *Ind. Eng. Chem.*, **31** [4] 416–25 (1939).—Modern developments in the experimental and theoretical aspects of turbulence in relation to the process of diffusion are reviewed. Illustrated. F.G.H.

Viscosity determinations of slag systems. J. R. Rait, Q. C. M'Millan, and R. Hay. *Jour. Roy. Tech. Coll.* [Glasgow], **4** (Part 3) [1] 449–66 (1939).—Results are given in graphs and tables of viscosity tests made for the binary systems CaO–SiO_2 and MnO–SiO_2 and for the ternary system CaO–Al_2O_3–SiO_2. A pronounced minimum occurs in the viscosity/composition isothermal curves at the compound CaO–SiO_2. The viscosities of the binary system MnO–SiO_2 and of the ternary system do not appear to be a continuous function of the composition. The effect of fluorspar on the viscosity of CaO–SiO_2 was determined by adding 1, 3, and 5% CaF_2 to each of three melts containing 44, 48, and 52% CaO and redetermining the viscosity at various temperatures from 1480° to 1620°C after each addition. In all cases CaF_2 diminished the viscosity but was less effective as the CaO content of the melt increased and as the temperature increased. The diminution of the viscosity of the melt was marked in all cases at low temperatures, indicating that fluorspar additions are most effective at low temperatures. The addition of 3% CaF_2 to a blast-furnace slag had the same effect. There was no change in viscosity for the mixture of 3% CaF_2 and blast-furnace slag over a period of 8 hours' heating at constant temperature; the authors therefore consider the generally accepted effect of fluorspar, represented by $2CaF_2 + SiO_2 = 2CaO + SiF_4$, to be vitiated, as an increase in CaO content which the equation predicts would produce an alteration in viscosity at constant temperature. For the open-hearth furnace slags (the FeO–MnO–SiO_2 system) the authors studied the MnO–SiO_2 binary system because the melts are not reduced in H_2 and the Mo furnace employed in previous work could be used. Sufficient data has not been obtained for accurate construction of the viscosity/composition isotherms over the whole range of the MnO–SiO_2 system. The data indicate that the viscosity decreases with increasing MnO, the eutectic mixture having the highest viscosity of the melts examined. With increasing SiO_2 beyond the eutectic, it appears that the viscosity will increase rapidly. The highly viscous nature of the siliceous slags was attributed by Feild to polymerization of the silica molecules. Thermal evidence in the literature shows that the compound tephroite ($2MnO \cdot SiO_2$) undergoes peritectic dissociation and is largely dissociated in melting; it has the lowest viscosity of the melts examined. W.H.B.

SEPARATE PUBLICATION

Volumetric Studies of Molybdenum. Metallurgical Division Progress Report No. 28, Analytical studies. C. E. Arrington and A. C. Rice. *U. S. Bur. Mines Repts. Investigations*, No. 3441, 52 pp. Free.—The report consists of three parts: (1) reduction and use of oxidants, (2) alpha-benzoinoxime volumetric method and comparison with gravimetric method, and (3) separation of molydenum from tungsten. R.A.H.

PATENTS

Complete dehydration and fusion of borax which is partially dehydrated. Chemische Fabrik Grünau A.-G. Ger. 674,253, March 23, 1939 (Aug. 27, 1936); IV*b*/12*i*. 40.—Partially dehydrated borax is completely dehydrated and fused by the direct action of heated gases in a melting chamber from which the melt is discharged through an opening at the base. The fine-grain charge to be treated is blown, together with heated gases, through one or several jets or nozzles into an upright melting shaft from above. D.A.B.

Hydrous silicate gel and method of making. E. W. Rembert (Johns-Manville Corp.). U. S. 2,165,578, July 11, 1939 (April 29, 1935).—In a process of producing insoluble silicates, the steps comprise disseminating a slightly soluble compound of amphoteric metal in an aqueous medium and slowly adding a soluble silicate to such medium in amount suitable to precipitate a simple silicate of the amphoteric metal and at a rate adapted to maintain a soluble silicate concentration in such medium during reaction below the concentration at which an insoluble silicate is formed of a dense granular structure having a relatively low adsorption efficiency, the rate being such that the time consumed in adding the soluble silicate is at least one-half hour.

Manufacture of sodium aluminate. W. S. Wilson and A. J. Lobdell, Jr. (Monsanto Chemical Co.). U. S. 2,165,187, July 4, 1939 (Dec. 26, 1935).—Sodium aluminate having an Al_2O_3/Na_2O weight ratio of substantially 1.4, an aqueous solution of which is relatively stable and further characterized in that it contains substantially 0.5% SiO_2 based on total solids.

Silicon hydroxide. Max H. Kliefoth (Sherwin-Williams Co.). Can. 381,909, June 6, 1939 (Dec. 30, 1936; in U. S. Nov. 14, 1936).—A method for making

silicon hydroxide comprises adding a solution of ammonium silicofluoride to ammonia in excess. G.M.H.

Silicon recovery. JOSEPH ERINGER. Can. 381,798, June 6, 1939 (Oct. 12, 1937).—A process for obtaining silicon from silicofluorides consists in acting on a silicofluoride with an electropositive metal *in vacuo* and separating the silicon thus formed from the products of the reaction. G.M.H.

White titanium pigment and method of preparing. W. F. WASHBURN, ROY DAHLSTROM, AND A. T. MCCORD (National Lead Co.). U. S. 2,166,082, July 11, 1939 (Aug. 26, 1936).—A substantially white titanium pigment having a blue-gray color tone comprises finely divided calcined particles of titanium dioxide and one or more light reflectance controlling agents selected from the group consisting of yttrium, molybdenum, palladium, tin, antimony, lanthanum, erbium, tungsten, platinum, gold, and thorium in a predetermined amount between 0.001% and 0.04% based on the weight of the titanium dioxide in intimate association and operative relation therewith, the light reflectance controlling agents having the property of imparting to the titanium dioxide a blue-gray color tone, the titanium pigment with the light reflectance controlling agents possessing the property of reflecting light of the relatively shorter wave lengths of the visible spectrum with slightly increased intensity over the average of total light reflected at all wave lengths and possessing a brightness not substantially lower than that of a similar but untreated white titanium pigment and essential pigment qualities not substantially inferior to the pigment qualities of the untreated white titanium pigment.

General

Richard Adams and his times. ANON. *Pottery & Glass Record*, **21** [5] 115 (1939).—With Josiah Wedgwood and Josiah Spode, Richard Adams of Cobridge, Staffordshire, can rightly be regarded as a founder of modern pottery. He learned the art of potting at the Holden Lane Pottery, near Hanley Green, which had belonged to his great-uncle, William Adams (1642–1712), who is credited with being one of the first to produce salt-glazed ware in Staffordshire. About the time Richard Adams was entering the pottery industry, salt-glazed ware had been carried to great perfection by the Astburys, Whieldon, and the Wedgwoods. In 1762, in North Staffordshire, there were about 150 of these factories employing 7000 workpeople, and £5000 was paid annually by the manufacturers to the government in salt duties. In 1770, Adams joined 27 other manufacturers in signing a document fixing a limit for prices. When salt-glazed pottery declined, Richard Adams, like his cousin Thomas Whieldon, would not make creamware; about 1790, he retired from the factory. His only son, William Adams, was a most energetic potter and controlled five separate works with branch offices in Liverpool and New York. See "Ten—," *Ceram. Abs.*, **11** [1] 44 (1932). A.B.S.

American patent system. FRANK E. BARROWS. *Ind. Eng. Chem.*, **30** [12] 1420–23 (1938). F.G.H.

American patent system aids chemical industry. BRUCE K. BROWN. *Ind. Eng. Chem.*, **31** [5] 580–84 (1939).—The fundamental principles of the American patent system are briefly described. F.G.H.

American way in industrial research. E. O. RHODES. *Ind. Eng. Chem.*, **31** [5] 549–56 (1939).—The programs of Mellon Institute and other industrial research institutions are described in detail. Illustrated. F.G.H.

Ceramic production in Belgium. M. RENARD. *Times Trade & Eng.*, **45** [904] 29 (1939). A.B.S.

Chemical study of siliceous industrial dusts. H. V. A. BRISCOE. *Science Progress*, **33** [131] 447–61 (1939).—B. presents a short résumé of the history of silicosis and its effects. Three methods of sampling the atmosphere for dust are discussed: volatile solid filters, soluble solid filters, and the "labyrinth." Samples taken were as follows: (1) small samples, 0.02 to 2 mg., from 5 to 10 liters of air for the determination of the mass concentration of dust solids, (2) larger samples, 20 to 100 mg., from 10 to 50 cu. m. of air for gravimetric analysis and approximate estimations of mass concentrations, and (3) very large samples, 10 to 200 g., for extensive chemical and physical investigations of the dust. The "solubility" of any one constituent of the mineral dust is dependent upon temperature, time, solid to solvent ratio, and particle size. No definite conclusions are reached, but this work is given as a challenge to other researchers to study and obtain the real cause for silicosis. See *Ceram. Abs.*, **17** [9] 317 (1938). C.H.R.

Factory floors in the chemical and related industries. REUEL C. STRATTON AND WARREN A. HOUGH. *Ind. Eng. Chem.*, **31** [3] 283–89 (1939).—The use of brick, tile, and magnesium oxychloride in the construction of factory floors is described. F.G.H.

Factory lighting and air protection. E. KAMMERER. *Maschinenbau*, **18** [7–8] 189–90 (1939).—The proper use of light for factory purposes is discussed. C.H.R.

Federal research contributes to the American way. DEXTER NORTH. *Ind. Eng. Chem.*, **31** [5] 574–80 (1939).—The bureaus of federal research, including those of ceramic significance, are briefly described. Illustrated. F.G.H.

Industrial medical organizations. JOHN J. PRENDERGAST. *Amer. Jour. Pub. Health*, **29** [6] 641 (1939).—Although large industrial organizations maintain complete medical departments, 99.5% of the industries employ less than 1000 workers, and 98.6% of them have less than 50 employees and are consequently unable to employ even a full-time physician. In most cases the services of a full-time nurse are not available, but adequate nursing service may be made available by nurses who are able to do stenographic or other types of office work. In addition, they may often act in an advisory capacity on problems in industrial hygiene. B.C.R.

Industrial minerals of Canada in 1938. L. H. COLE. *Can. Mining & Met. Bull.*, No. 326, pp. 273–90 (1939).—Canada produces 31 types of industrial minerals. Small amounts of bentonite have been produced in British Columbia and Manitoba, and there is a growing output in Alberta for use in oil-well drilling mud. The National Sewer Pipe Co., Hamilton, is using compounded applied ceramic glazes in the manufacture of sewer pipe, the only place on this continent where this process is being used. A circular tunnel kiln was installed in a pottery at Medicine Hat during 1938. Production of china clay at St. Remi d'Amherst should start in 1939. Feldspar production decreased about 30% in 1938; it is produced mainly in Ontario and Quebec. A deposit of spodumene has been found in Manitoba. Considerable interest is being shown in brucite-bearing limestone deposits in Ontario and Quebec. Large reserves of nepheline syenite occur in Ontario and are being developed. Glass sand is being produced at St. Remi. G.M.H.

Kraftile Co. exhibit. ANON. *Bull. Amer. Ceram. Soc.*, **18** [7] 272 (1939).

Libbey-Owens-Ford glass exhibit on Treasure Island. EARL AIKEN. *Bull. Amer. Ceram. Soc.*, **18** [7] 273 (1939).

Needs of our patent system. DELOS G. HAYNES. *Ind. Eng. Chem.*, **30** [12] 1430–32 (1938). F.G.H.

Occupational diseases in the glass industry. H. OTTO. *Glastech. Ber.*, **17** [5] 138–47 (1939).—33 references. J.F.H.

Owens-Illinois Pacific Coast Co. exhibit. ANON. *Bull. Amer. Ceram. Soc.*, **18** [7] 272 (1939).

Patent law and practice of foreign countries. THOMAS H. WEST. *Ind. Eng. Chem.*, **30** [12] 1424–30 (1938). F.G.H.

Patent litigation in 1938. NELSON LITTELL. *Ind. Eng. Chem.*, **31** [1] 120–23 (1939).—L. discusses numerous

cases which are fairly illustrative of the trend of decisions and of the elucidation of important points of patent law which were made during 1938. F.G.H.

Personalized protection. EDWARD R. GRANNISS. *Ind. Eng. Chem.*, **31** [6] 664–72 (1939).—Progress in the development of respirators is described. Illustrated. F.G.H.

Plant museum for process control and employee education. ANON. *Ceram. Ind.*, **27** [6] 428 (1936).—An excellent medium for educating plant personnel and controlling manufacturing processes is a plant museum. The display of defective ware helps to determine causes and prevent duplication of processing errors. The Locke Insulator Corp. museum is described. E.J.V.

Presence of "curious bodies" in the lungs of South African gold miners. ENID WILLIAMS. *Jour. Path. Bact.*, **48**, 475–76 (1939); *Chem. Abs.*, **33**, 4343 (1939).—"Curious bodies" resembling asbestosis bodies, some pale and some with black cores, were found in the lungs of gold miners exposed neither to asbestos nor to coal. The bodies may have arisen from chance inhalation of mineral fibers not necessarily related to asbestos or coal. They bore no relationship to the presence of lung lesions.

Prevention of silicosis by metallic aluminum: II. J. J. DENNY, W. D. ROBSON, AND DUDLEY A. IRWIN. *Can. Mining Jour.*, **60** [6] 332–43 (1939).—Methods have been devised at the McIntyre mine whereby an excellent dispersion of aluminum powder can be obtained in the underground atmosphere for the prevention of silicosis. For Part I see *Ceram. Abs.*, **18** [8] 225 (1939). G.M.H.

Report of Film Library Committee of the Society. H. E. SIMPSON, Chairman. *Bull. Amer. Ceram. Soc.*, **18** [7] 250–52 (1939).

Safety measures for protection against the carelessness of man. H. LAUERTEIG. *Maschinenbau*, **18** [9–10] 217–18 (1939).—L. discusses the use of safety devices, design changes of the product for safety, and automatic safety devices. C.H.R.

Silica aerogel. J. F. WHITE. *Ind. Eng. Chem.*, **31** [7] 827–31 (1939).—The structure, preparation, and previous data on the thermal conductivity of silica aerogel are briefly reviewed. The effect of variables on its thermal conductivity is discussed in detail. Illustrated. F.G.H.

X-ray car used in the fight against dust lung. ANON. *Maschinenbau*, **18** [9–10] 246 (1939).—A mobile X-ray unit is used to study industrial dust hazard. C.H.R.

BOOK

Location of Industry in Great Britain. ANON. Political and Economic Planning Rept., London, 1939. Price 10s 6d. Reviewed in *Pottery & Glass Record*, **21** [6] 148 (1939). A.B.S.

PATENTS

Colored roofing granule. H. R. GUNDLACH (Central Commercial Co.). U. S. 2,163,678, June 27, 1939 (July 1, 1936).

Coloring roofing granules. H. R. GUNDLACH AND PAUL TEETOR (Central Commercial Co.). U. S. 2,163,679, June 27, 1939 (April 8, 1935).

Siliceous product and method of making. A. B. CUMMINS AND L. B. MILLER (Johns-Manville Corp.). U. S. 2,164,500, July 4, 1939 (Nov. 29, 1935).—A process of manufacturing a powdered diatomaceous earth product suitable for use as a filter aid, filler, etc., comprises forming a mixture of finely divided diatomaceous earth with a relatively small amount of a nonmetallic acidic flux selected from the group consisting of hydrofluosilicic acid and a boric acid not in excess of about 10% by weight of the diatomaceous earth and calcining the mixture to cause interaction of the flux and diatomaceous earth but not sufficiently to bring about the formation of hard, burned granules.

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Chem. Listy
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Jour. Amer. Soc. Agron.
Jour. Australian Chem. Inst.
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Kolloid. Zhur.
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Mineral. Syr'e
Mining Rev. S. Australia
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Society Nominations B.....	H. E. Marley	G. H. McIntyre	J. T. Littleton	J. E. Eagle	L. J. Trostel	J. E. Rankin	R. L. Clare	J. R. Beam
Division Nominations	P. E. Thornton W. A. Weldon	W. N. Harrison	A. N. Finn U. E. Bowes					
Papers and Program	W. A. Weldon E. de F. Curtis	J. D. Tetrick	W. R. Lester A. K. Lyle	F. E. Finch R. G. O'Meara S. S. Cole	R. S. Bradley G. S. Diamond W. R. McLain E. B. Read	H. R. Straight H. Z. Schofield L. R. Whitaker	H. E. Davis D. F. Albery	R. Russell, Jr. F. C. Henderson J. R. Kauffman
Membership	K. E. Smith	E. C. Aydelott	J. T. Ogden	R. C. Meeker	C. A. Freeman	J. H. Stewart J. H. Grady	J. L. Carruthers	Hewitt Wilson
Standards	K. E. Smith	C. R. Amberg	G. W. Morey		S. M. Swain E. H. Van Schoick	H. C. Plummer		J. H Koenig
Research	C. M. Harder	R. L. Fellows	W. Weyl	V. J. Roehm	D. W. Ross	R. B. Keplinger		J. R. Beam
Data	E. de F. Curtis	E. C. Dexheimer	A. E. Badger	F. A. Guignon	C. L. Thompson	H. G. Schurecht	E. E. Marbaker	H. C. Harrison
Rules	W. A. Weldon E. de F. Curtis	G. H. Spencer-Strong	A. N. Finn	J. E. Eagle	K. E Buck	G. H. Duncombe, Jr.		A. M. Hossenlopp
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Industrial Management	Theodore Lenchner				Furman South, Jr.			